Service

Commercial and Recreational Mobile Generator Sets

Models:

5ERKM
4EFRKM

ISO 9001
KOHLER GENERATORS
INTERNATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-6079 3/00

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IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

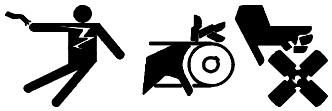
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Battery

WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove wristwatch, rings, and other jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove wristwatch, rings, and other jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

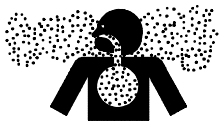
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner removed.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building or vehicle. Do not obstruct the exhaust outlet when parking your vehicle. The exhaust gases must discharge freely to prevent carbon monoxide from deflecting into the vehicle.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

Installing the exhaust tail pipe. Carbon monoxide can cause severe nausea, fainting, or death. Install the exhaust system tail pipe to prevent the drawing of discharged exhaust gases into the vehicle interior through windows, doors, air conditioners, and other openings. Do not use flexible tail piping because it could crack and allow lethal exhaust fumes to enter the vehicle.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the vehicle's occupants, install a carbon monoxide detector. Consult the coach builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

Fuel System

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Gasoline—Store gasoline only in approved red containers clearly marked GASOLINE.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Hazardous Noise

⚠ CAUTION

Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/Electrical Shock

⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING

Hazardous voltage.
Backfeed to the utility system can cause severe injury, death, or property damage.

Connect the generator set to the building's electrical system only through an approved device and after the building's main switch is opened.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove wristwatch, rings, and jewelry before servicing the equipment.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator. *(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)*

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/campground electrical system only through an approved device and after the building/campground main switch is opened. Backfeed connections can cause serious injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a transfer switch to prevent interconnection of the generator set power and other sources of power.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove rings, wristwatch, and jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically.
(600 volts and under)

Hot Parts

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Combustible materials. Fire can cause severe injury or death. A hot exhaust system can ignite adjacent combustible materials. Do not locate electrical wiring, fuel lines, or combustible materials above the exhaust muffler. Exercise caution when parking your vehicle to prevent the exhaust system and hot exhaust gases from starting grass fires.

Combustible materials. Fire can cause severe injury or death. A hot generator set can ignite debris in the compartment. Keep the compartment and generator set clean and free of debris and combustible materials to minimize the possibility of fire. Do not block the fuel/oil drain opening in the generator set mounting tray. Cut a corresponding hole in the subfloor, if used, for the drain opening.

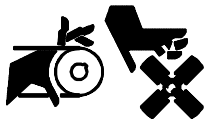
Moving Parts

⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Tightening the hardware. Flying projectiles can cause severe injury or death. Loose hardware can cause the hardware or pulley to release from the generator set engine and can cause personal injury. Retorque all crankshaft and rotor hardware after servicing. Do not loosen the crankshaft hardware or rotor thrubolt when making adjustments or servicing the generator set. Rotate the crankshaft manually in a clockwise direction only. Turning the crankshaft bolt or rotor thrubolt counterclockwise can loosen the hardware.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Canadian installations only. For standby service connect the output of the generator set to a suitably rated transfer switch in accordance with Canadian Electrical Code, Part 1.

NOTICE

This generator set does not comply with United States Coast Guard (USCG) requirements and must not be used for marine applications. For marine installations use only generator sets specified for marine use. USCG Regulation 33CFR183 requires that a generator set must be ignition protected when used in a gasoline-fueled environment.

Notes

Introduction

This manual provides troubleshooting and repair instructions for 5ERKM and 4EFRKM model generator sets, controllers, and accessories.

Refer to the engine service manual for generator set engine service information.

This manual may be used for models not listed on the front cover.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably-trained maintenance personnel, familiar with generator set operation and service.

Before installing a mobile generator set, obtain the most current installation manual from your local distributor/dealer. Only qualified persons should install the generator set.

x:in:001:002:a

Service Assistance

Service Information

Please contact a local authorized distributor/dealer for sales, service, or other information about Kohler Generator Division products.

To locate a local authorized distributor/dealer inside the U.S.A. and Canada

- Look on the product or in the information included with the product
- Consult the Yellow Pages under the heading Generators— Electric
- Visit the Kohler Generator Division web site at www.kohlergenerators.com
- Call 1-800-544-2444

To locate a local authorized distributor/dealer outside the U.S.A. and Canada

- Look on the product or in the information included with the product
- Consult the telephone directory under the heading Generators—Electric
- Visit the Kohler Generator Division web site at www.kohlergenerators.com
- Contact the nearest regional office

Africa, Europe, Middle East
London Regional Office
Langley, Slough, England
Phone: (44) 1753-580-771
Fax: (44) 1753-580-036

Australia
Australia Regional Office
Queensland, Australia
Phone: (617) 3893-0061
Fax: (617) 3893-0072

China
China Regional Office
Shanghai, People's Republic of China
Phone: (86) 21-6482 1252
Fax: (86) 21-6482 1255

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80-2284270
(91) 80-2284279
Fax: (91) 80-2284286

Japan
Japan Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, U.S.A.
Phone: (941) 619-7568
Fax: (941) 701-7131

South East Asia
Singapore Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

Product Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Generator Set Identification Numbers

Record the product identification numbers from the generator set nameplate(s).

Model Number _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Number _____

Serial Number _____

1.1 General

The 5ERKM and 4EFRKM units are powered by a one-cylinder, air-cooled, four-cycle gasoline engine.

Kohler Co. develops all Kohler mobile generator set ratings using accepted reference conditions of 25°C (77°F) and pressure of 98.9 kPa (29.2 in. Hg) dry barometer. ISO 3046 and ISO 8528-1 include reference conditions and output calculations. Obtain technical information bulletin (TIB-101) on ratings guidelines for complete ratings definitions.

1.2 Engine

Engine Specifications	
Engine manufacturer	Kohler
Engine model	CS12
Number of cylinders	1
Cylinder block material	Aluminum
Cylinder head material	Aluminum
Piston rings	2 compression 1 oil control
Governor	Mechanical
Bore x stroke, mm (in.)	85 x 63 (3.35 x 2.48)
Displacement, L (CID)	0.357 (21.79)
Compression ratio	8.1:1
Horsepower, 60/50 Hz	11.5/8
RPM, 60/50 Hz	3600/3000
Lubrication system	Splash
Lube oil capacity L (U.S. qts)	2.0 (2.1)
Oil recommendation, API	SC or SH
Battery voltage, standard, DC	12
Battery CCA recommendation, min.	250
Battery charging	10 amps
Starter motor	Bendix automotive type

1.3 Fuel

Fuel System Specifications	
Fuel recommendation	Unleaded 87 octane
Fuel pump	Electric
Fuel pump, max. lift, m (ft.)	0.9 (3)
Fuel pump operating, kPa (psi)	13.8–24.1 (2.0–3.5)
Fuel pump inlet hose ID, mm (in.)	6.35 (0.25)

1.4 Generator

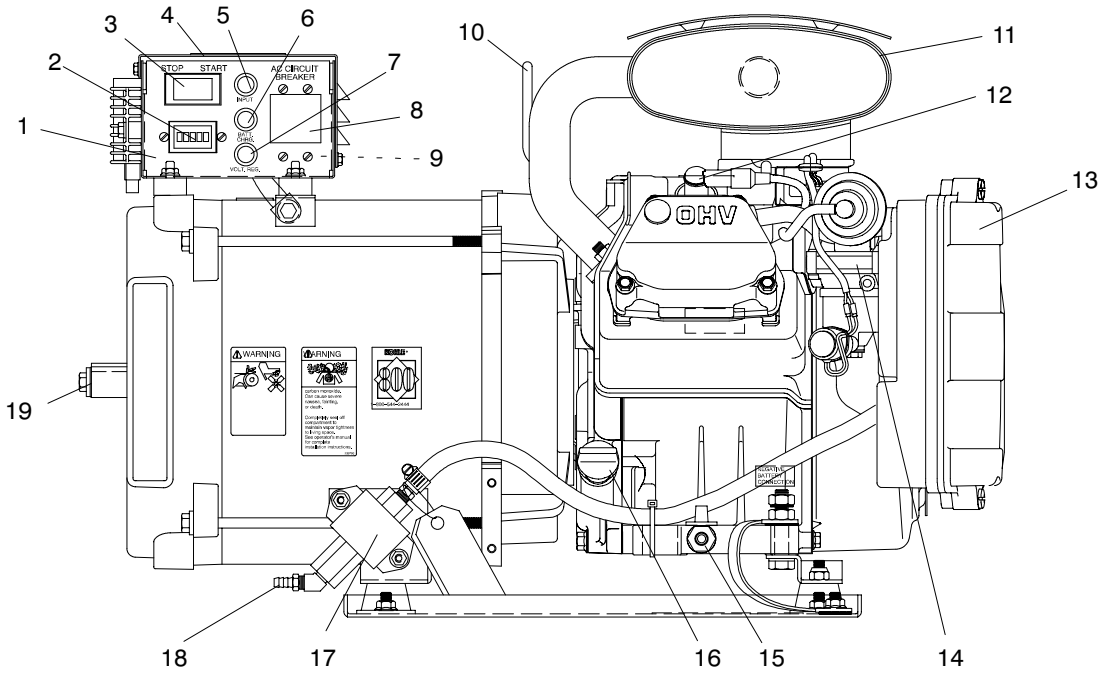
Component Specifications	
Hot exciter field voltage/current readings at rated voltage	
No load (63 Hz) (volts/amps)	10.1/4.4
Full load (60 Hz) (volts/amps)	50.5/8.5
Cold main field (rotor) resistance (ohms)	3.7
Stator output voltages with separately excited generator, using 12-volt battery (60 Hz only)	
1–2, 3–4, 33–44 (VAC)	145
55–66 (VAC)	190
B1–B2 (VAC)	14
Cold stator resistance	
1–2, 3–4, 33–44 (ohms)	0.32
55–66 (ohms)	1.70
B1–B2 (ohms)	0.05

1.5 Torque

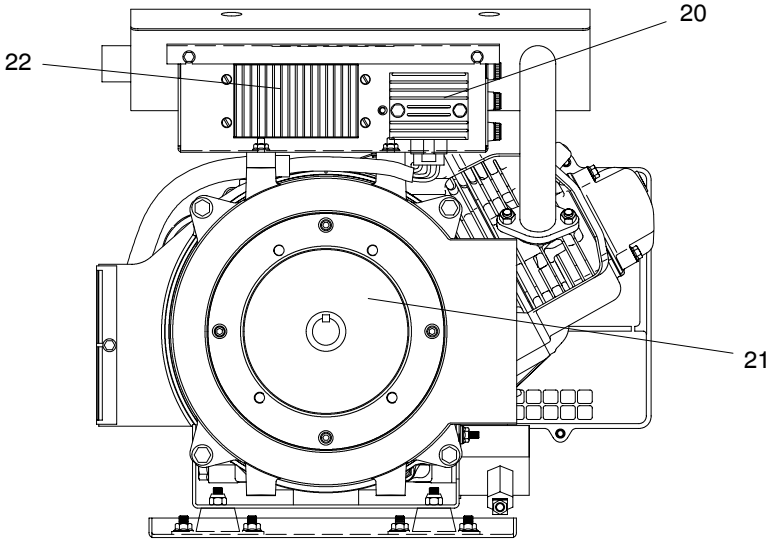
Component	Torque Nm (in. lb.)
Rotor bolt	23.1 (204)
Generator overbolts	13.6 (120)
Mounting plate to end bracket bolts	6.8 (60)
Lift eyebolts	19.0 (168)
Generator adapter to engine bolts	14.9 (132)
Engine oil drain boss (inside generator adapter)	47.5 (420)
Generator adapter to exhaust manifold	13.6 (120)
Spark plug	12–17 (106–150)

1.6 Service Views

SERVICE VIEW



ENGINE-END VIEW



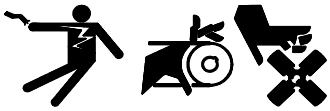
FV-277000

1. Controller
2. Hourmeter
3. Start/Stop switch
4. Nameplate (top)
5. Input fuse
6. Battery charging fuse
7. Voltage regulator fuse
8. AC circuit breaker
9. Remote start connector (nonservice side)
10. Lifting eye
11. Muffler
12. Spark plug
13. Air intake silencer
14. Carburetor
15. Oil drain valve
16. Oil check
17. Fuel feed pump
18. Fuel inlet
19. Extended shaft (generator specification available)
20. Engine battery charging voltage regulator
21. End bracket cover plate
22. PowerBoost™IIIE voltage regulator

Figure 1-1 5ERKM/4EFRKM Service Views

2.1 General

⚠ WARNING

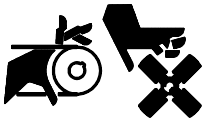


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Note: See the generator set operation manual for the service schedule and other service not included in this manual.

2.2 Lubrication System

Use oil that meets the American Petroleum Institute (API) classification of SC or SH. Using unsuitable oil or neglecting an oil change may result in engine damage that is not covered by the engine warranty. Figure 2-1 shows the recommended Society of Automotive Engineers (SAE) viscosity designation for given operating temperature ranges.

Do not mix different oil brands. Incompatibility could cause a breakdown of lubricating ingredients and reduce engine protection.

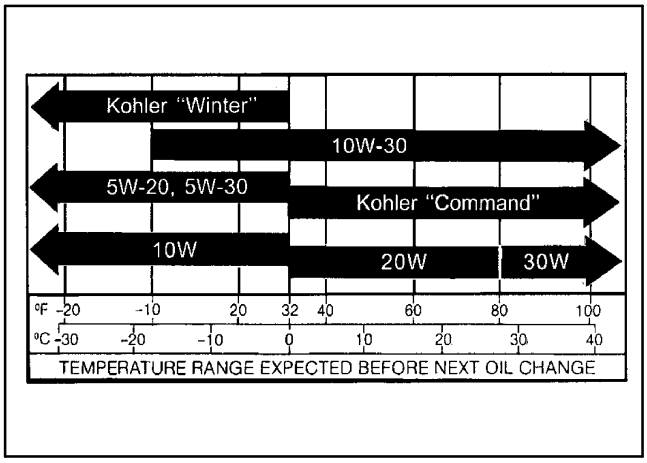


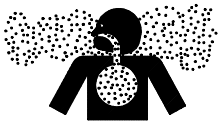
Figure 2-1 Recommended SAE Viscosity Grades

2.3 Air Intake System

At the interval specified in the service schedule, inspect, clean, or replace the air filter element.

2.4 Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Exhaust System. Check for exhaust leaks and blockages. Check the muffler and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, exhaust line, exhaust clamps, and muffler) for cracks and corrosion.

- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace the exhaust clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Check the exhaust gas color. If the exhaust is blue or black, contact your local distributor/dealer.
- Visually inspect for exhaust leaks. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector is (1) in the vehicle, (2) functional, and (3) energized whenever the generator set operates.

m:op:001:003

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Explosive fuel vapors can cause severe injury or death. Take additional precautions when using the following fuels:

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

3.1 General

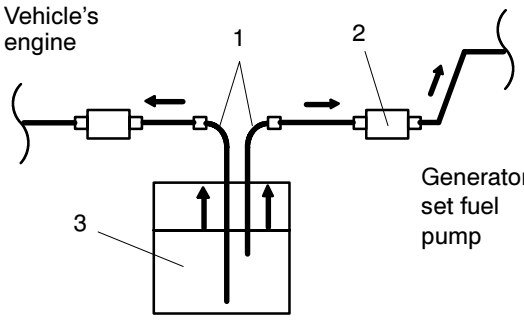
In most installations, both the generator set and the vehicle's engine operate from a common fuel tank with a dual dip tube. The generator set's dip tube may be shorter than the vehicle engine's dip tube. With this arrangement, fuel may not be available to the generator set when the fuel supply is low. See Figure 3-1 for a fuel system schematic.

3.2 Fuel Pump

Electric fuel pumps draw fuel from the fuel tank through a filter and supply clean fuel at the proper pressure and quantity to the generator set engine carburetor.

Fuel Pump Test Procedure:

1. Connect the inlet side of the pump to a fuel source.
2. Disconnect the outlet hose from the fuel filter and place the end in a container to catch the fuel.
3. Disconnect the P9 connector.
4. Connect the positive terminal (70) of the fuel pump to the positive terminal (+) of a 12-volt battery.
5. Connect the negative terminal (N) of the fuel pump to the negative terminal (–) of the battery. The pump should operate and fuel should discharge from the pump outlet. If the pump does not operate, replace the pump.



1. Dual dip tubes
2. Fuel filter
3. Fuel tank

Figure 3-1 Fuel System Schematic, Typical

3.3 Carburetor Troubleshooting

This section is for fuel-related problems and basic carburetor troubleshooting. See Figure 3-2 for carburetor component identification.

Note: When troubleshooting the fuel system, it is important to have an adequate fuel supply.

A lean or rich fuel condition can reduce power output and cause poor acceleration.

Symptoms of a lean condition:

- Hard starting
- Stalling
- Hunting

Symptoms of a rich condition:

- Hard starting
- Stalling
- Percolation
- Flooding
- Leaking carburetor

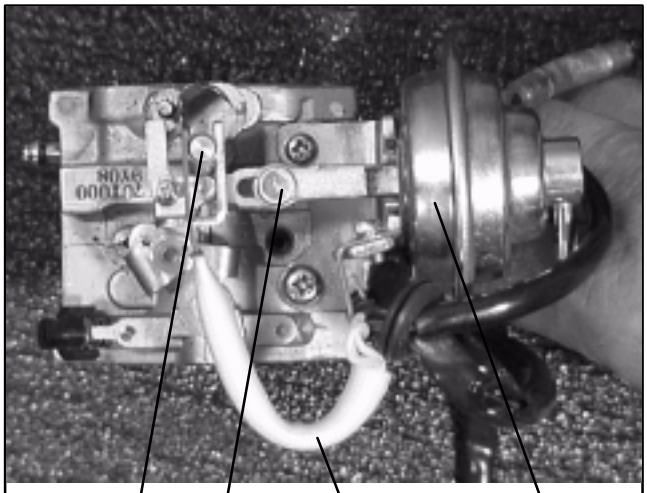
If a rich condition occurs, remove the air cleaner element and observe the choke plate to ensure that it is fully open. The choke will not fully open until the engine is warm. If the choke does not fully open, test the bi-metallic strip and the choke pull-off. See Figure 3-2. Replace components as necessary.

Choke Pull-off Vacuum Solenoid Test Procedure:

1. Remove the vacuum hose that is connected to the back of the choke pull-off vacuum solenoid.
2. Push and hold the choke linkage into the choke pull-off vacuum solenoid.
3. Seal the vacuum port on the back of the solenoid and release the choke linkage. If the choke linkage moves back to the original location while the vacuum port is sealed, replace the choke pull-off vacuum solenoid.

Bi-metallic Strip Test Procedure:

1. Start and run the generator set until it reaches normal operating temperature. (5–10 minutes).
2. If the choke plate lever can be rotated counterclockwise adjust or replace the bi-metallic strip.



1. Choke pull-off
2. Bi-metallic strip
3. Choke linkage
4. Choke plate lever

Figure 3-2 Fuel System Exploded View

3.3.1 Hard Starting

A flooded engine, an improperly adjusted or inoperative choke, or a dirty carburetor (lean condition) can cause hard starting.

3.3.2 Stalling

A dirty carburetor can cause stalling. Clogged idle air bleeds, idle air passages, or an idle discharge port can cause stalling because of a lean condition. To remedy this condition, clean or adjust the carburetor.

3.3.3 Flooding

Flooding occurs from a float level set too high, an inoperative bi-metallic strip, an inoperative choke pull-off, a sticking choke plate or float, or a fuel inlet needle held off its seat either by improper seating or dirt particles. A punctured or leaking float admitting fuel becomes gas-logged causing a heavy float, high fuel level, and flooding.

3.3.4 Hunting

A low fuel level because of an improperly adjusted float, a clogged main jet, restricted main jet passages, or an improperly sized main jet for the application can cause hunting. To remedy this condition, clean, adjust, or replace inoperative components.

An incorrect throttle linkage adjustment, a binding throttle linkage, a sticking throttle shaft, or a loose throttle shaft in the throttle body or bore can cause inconsistent idle speed.

3.3.5 Leaking Carburetor

Loose fuel connections, a cracked carburetor body, a sticking fuel inlet needle, or an inoperative float can cause a leaking carburetor. Adjust, repair, or replace the affected components.

3.4 Governor

The factory adjusts the governor and further adjustments should not be necessary.

Note: Never tamper with the governor settings to increase the generator output. Overspeeding can cause equipment parts to exceed design limitations, resulting in component failure.

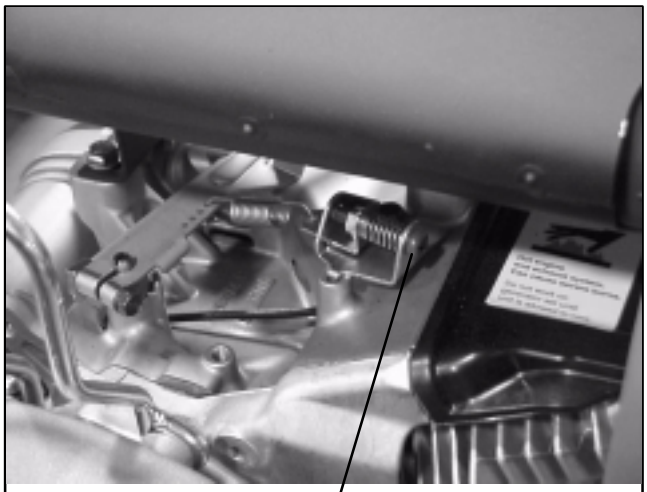
3.5 60 and 50 Hz Conversions

To convert the generator set to 50 or 60 Hz follow the procedure below.

Governor 50 or 60 Hz Conversion Procedure:

1. Adjust the generator frequency by adjusting the generator speed adjusting screw. Using a frequency meter set the no load speed at 52.5 Hz for 50 Hz operation or 63 Hz for 60 Hz operation.

2. Adjust the voltage regulator volt/Hz roll-off point. Refer to Section 5.2.2.



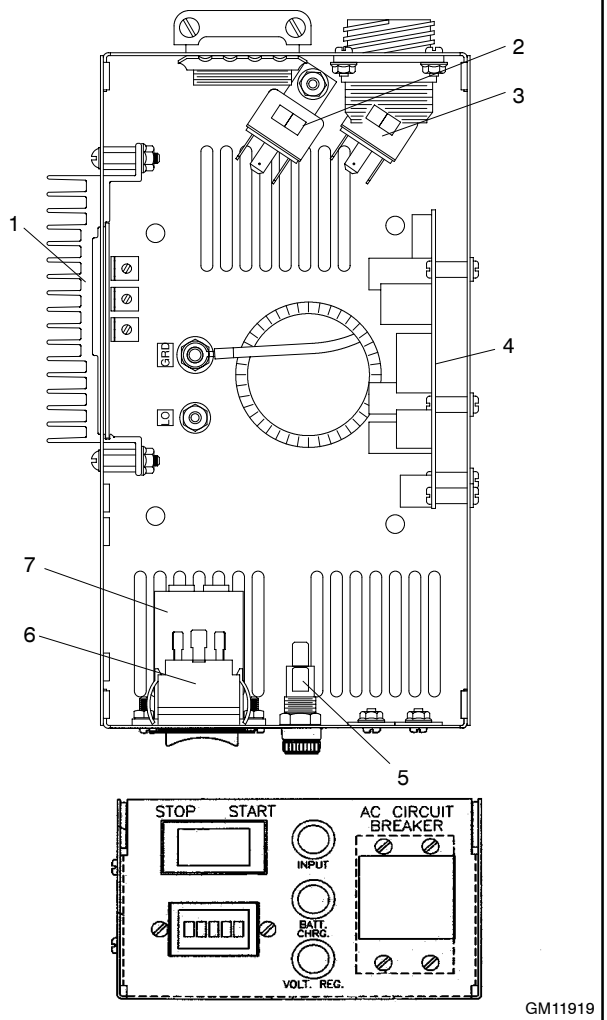
1. Generator speed adjusting screw

Figure 3-3 Governor 60 Hz to 50 Hz Conversion

Notes

4.1 Sequence of Operation

This section describes the controller sequence of operation during the generator start, run, stop, and fault shutdown modes and describes the relay testing procedures. Use this section as a starting point for controller fault identification. Use the LEDs on the controller circuit board to assist in the troubleshooting process. An illuminated LED indicates that the respective relay is receiving power; the LED does not indicate whether that relay is energized or working properly. Unfold and use the wiring diagram in Section 8.5 to follow the sequence of operation in this section.



1. PBIIIE voltage regulator
2. K20 relay
3. K25 relay
4. Controller circuit board
5. Fuses
6. Start/stop switch
7. Hourmeter

Figure 4-1 Controller

4.1.1 Start

Press the start/stop switch to the START position to close the start/stop switch between N and 47 (local or remote).

The K2 relay energizes and LED2 illuminates. The normally open K2 contacts close energizing the K3 relay (LED3 lights), fuel pump (FP), choke heater (CHTR), antidiesel solenoid (ADS), ignition (IGN), hourmeter (HR), and the main field (FP and FN).

Flashing of the main field occurs when the K2 contacts close.

The normally open K3 contacts close energizing the K20 relay. The normally open K20 contacts close, energizing the starter relay (SR). The SR normally open contacts close energizing the starter motor (SM).

4.1.2 Run

The bridged rectifier (BR1) receives AC voltage (12–15 volts) through the B1 and B2 windings of the stator.

The K1 relay energizes (LED1 lights).

The normally open K1 contacts close maintaining voltage to the K2 relay, allowing the function of the fuel pump (FP), choke heater (CHTR), antidiesel solenoid (ADS), ignition (IGN), and hourmeter (HR).

The normally closed K1 contacts open, ending the flashing by preventing battery voltage to the main field (+) and (–).

The K6 relay energizes. The normally open K6 contacts close, latching the K6 relay on. The normally closed K6 contacts open, preventing inadvertent starter engagement by disabling the the K3 relay.

The K3 relay deenergizes (LED3 off). The K3 contacts open, deenergizing the K20 relay. The K20 contacts open, deenergizing the starter relay and starter motor.

At the same time the K1 relay energizes, the time delay for the K5 relay starts. After 5–10 seconds, the K5 relay energizes (LED 5 lights).

The normally open K5 contacts close permitting the function of the engine safety shutdown switch.

4.1.3 Stop

Close the start/stop switch between N and 43 (local or remote).

The K4 relay energizes (LED4 lights).

The normally closed K4 contacts open, disabling the fuel pump (FP), choke heater (CHTR), antidiesel solenoid (ADS), and ignition (IGN).

The normally open K4 contacts close, latching the circuit to the K4 relay until the generator set comes to a complete stop.

4.1.4 Low Oil Level (LOL) Safety Switch

When the oil level is low, the LOL shutdown switch contacts close energizing the K4 relay (LED4 lights). The generator set shuts down, as described in Section 4.1.3.

4.2 Controller Circuit Board

The controller circuit board has light emitting diodes (LEDs) that indicate the presence of relay coil power. When any of the relays K1–K5 receives power, the corresponding LED lights.

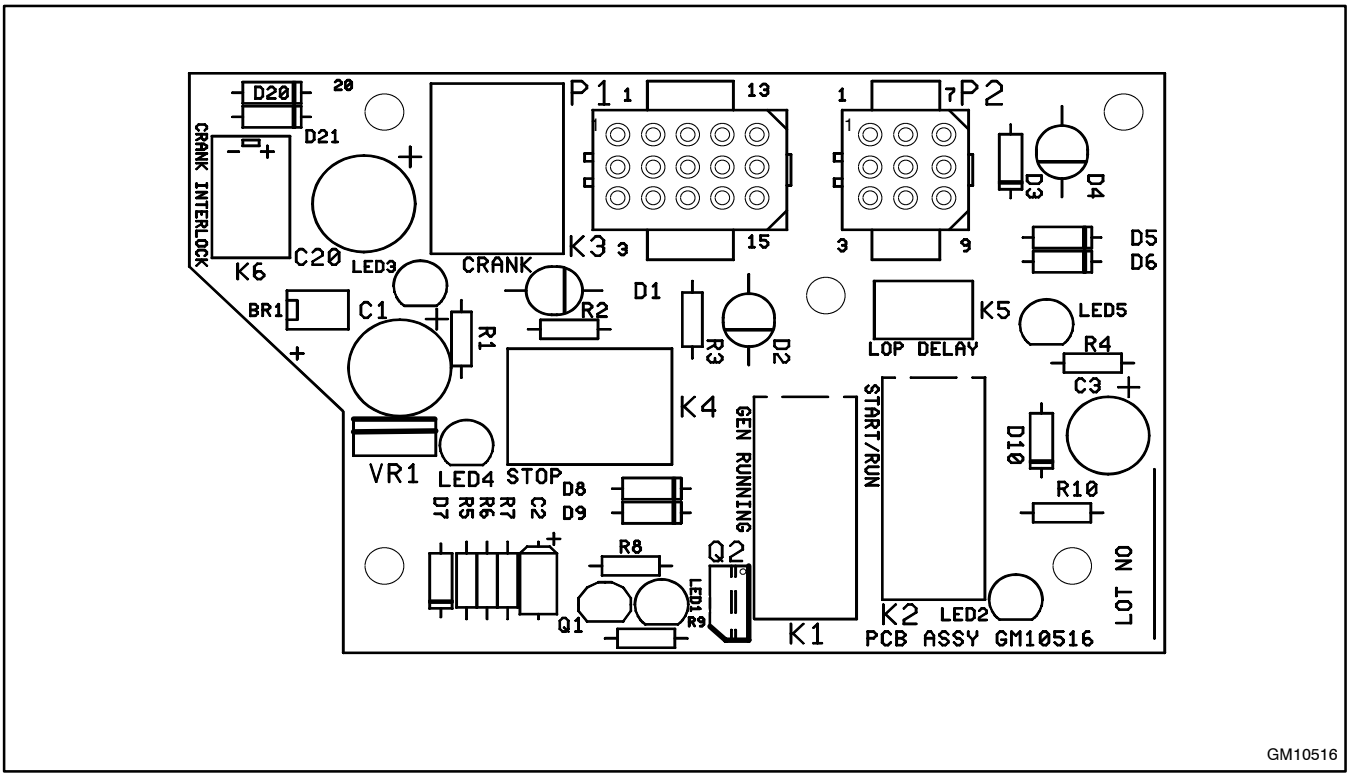


Figure 4-2 GM10516 Controller Circuit Board

4.3 Troubleshooting

Use the following flow chart as an aid in troubleshooting the main circuit board and the entire generator set. If the prescribed remedy does not correct the problem, the circuit board may have to be replaced. Use this chart for component testing only. Always check the continuity of the wires between components. Always disconnect external components (remote start/stop switches, the engine gauge panel, dry relay contact kits, etc.) before performing troubleshooting procedures.

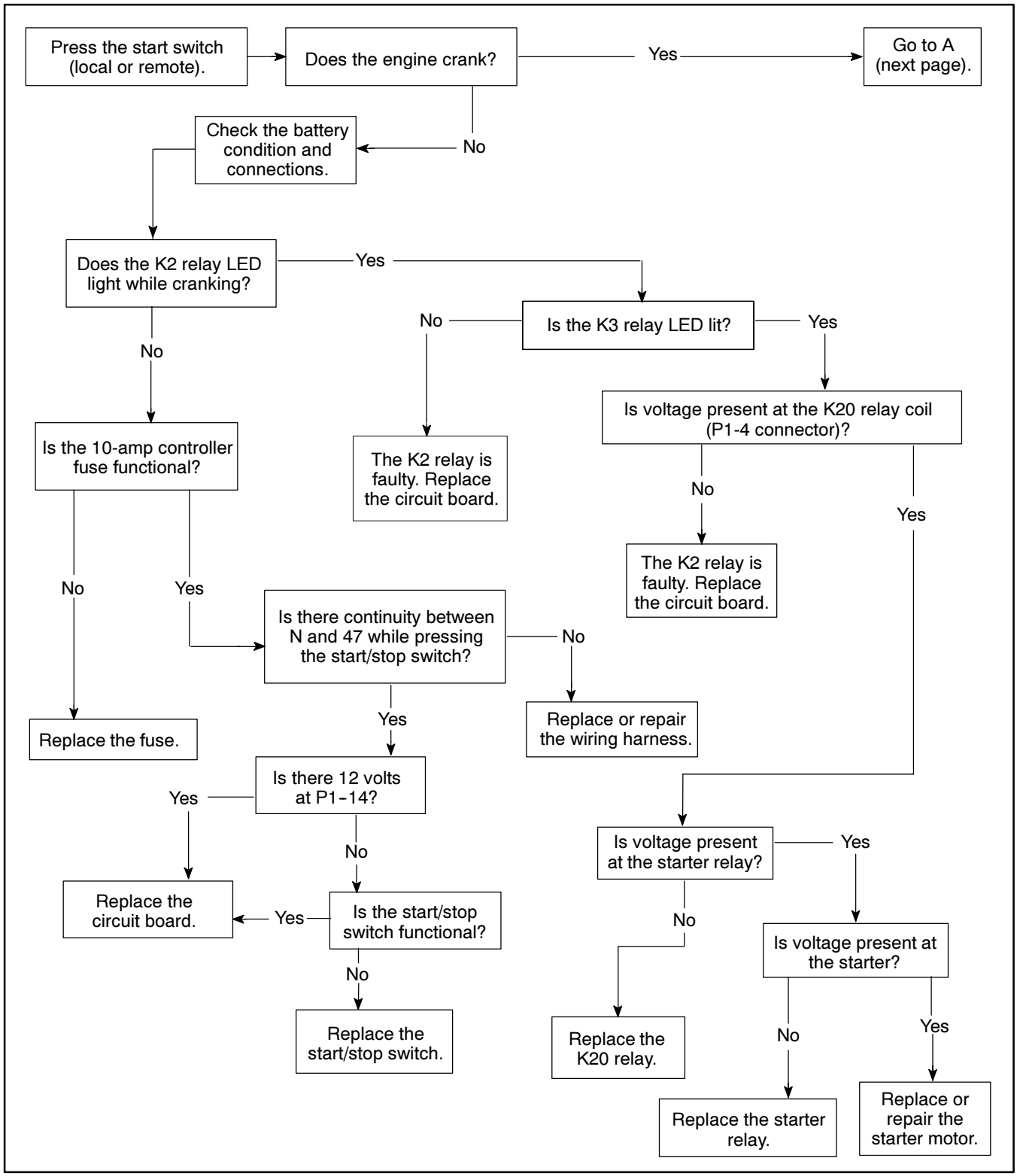


Figure 4-3 Troubleshooting the Relay Controller Circuit Board (1 of 4)

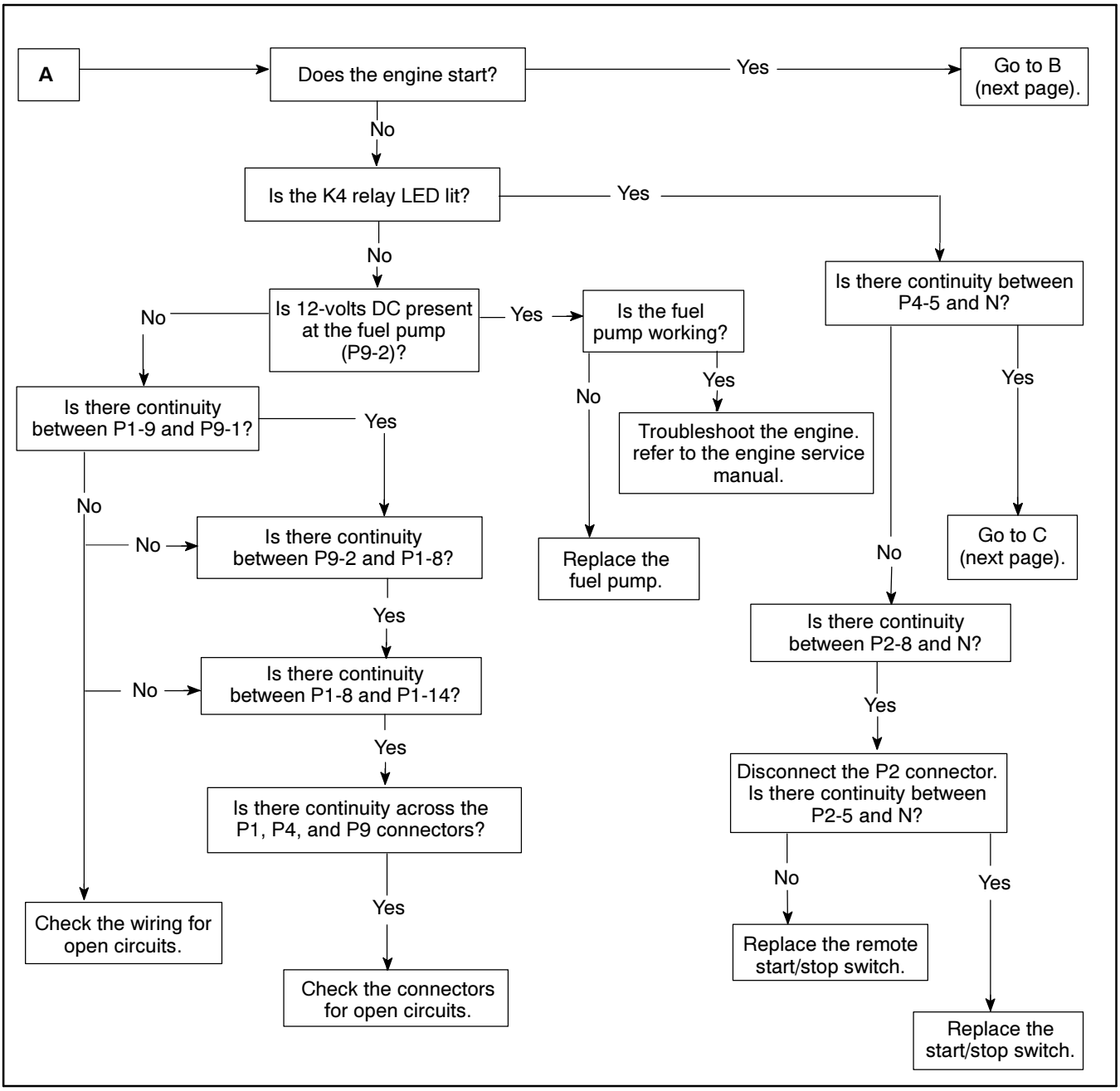


Figure 4-4 Troubleshooting the Relay Controller Circuit Board (2 of 4)

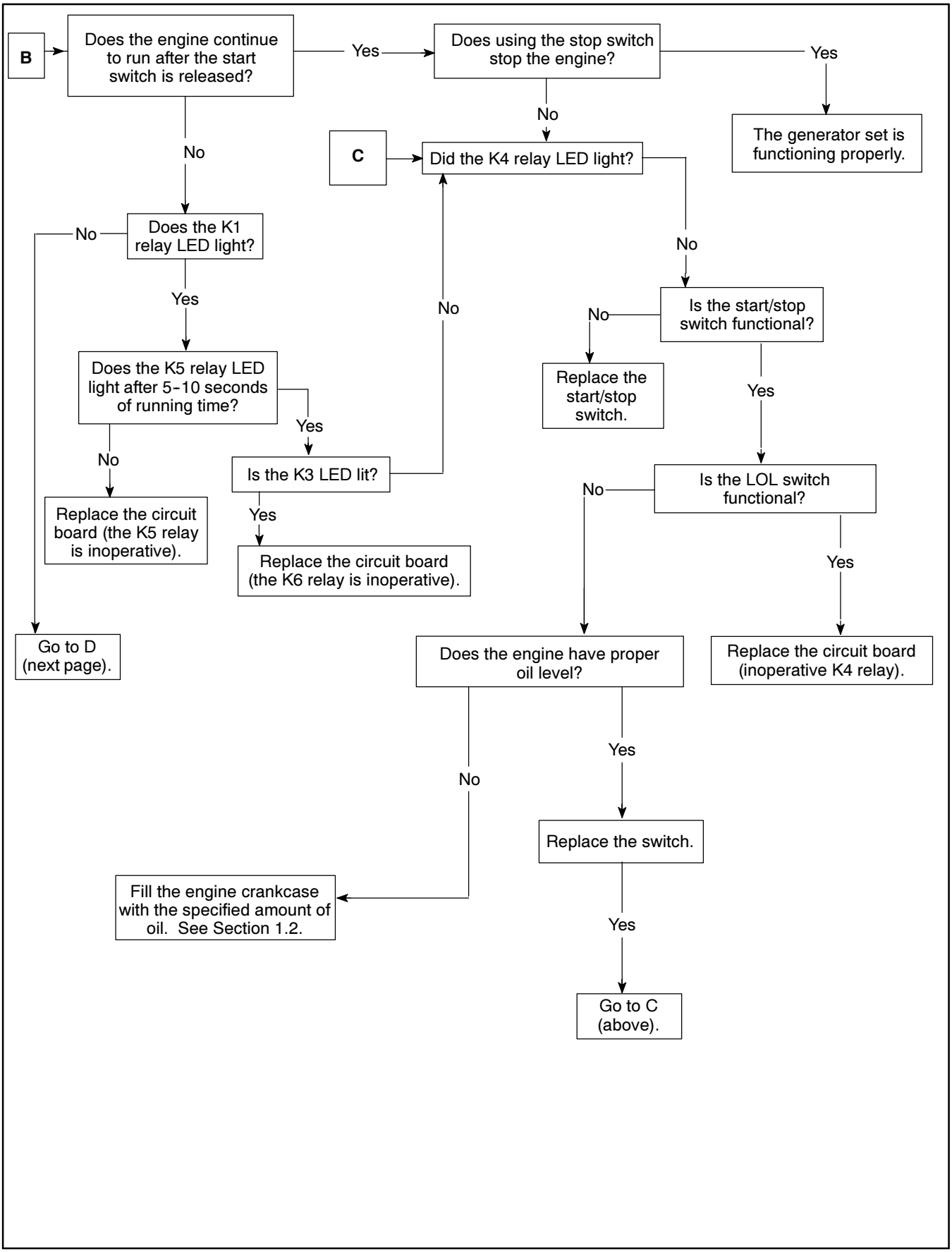


Figure 4-5 Troubleshooting the Relay Controller Circuit Board (3 of 4)

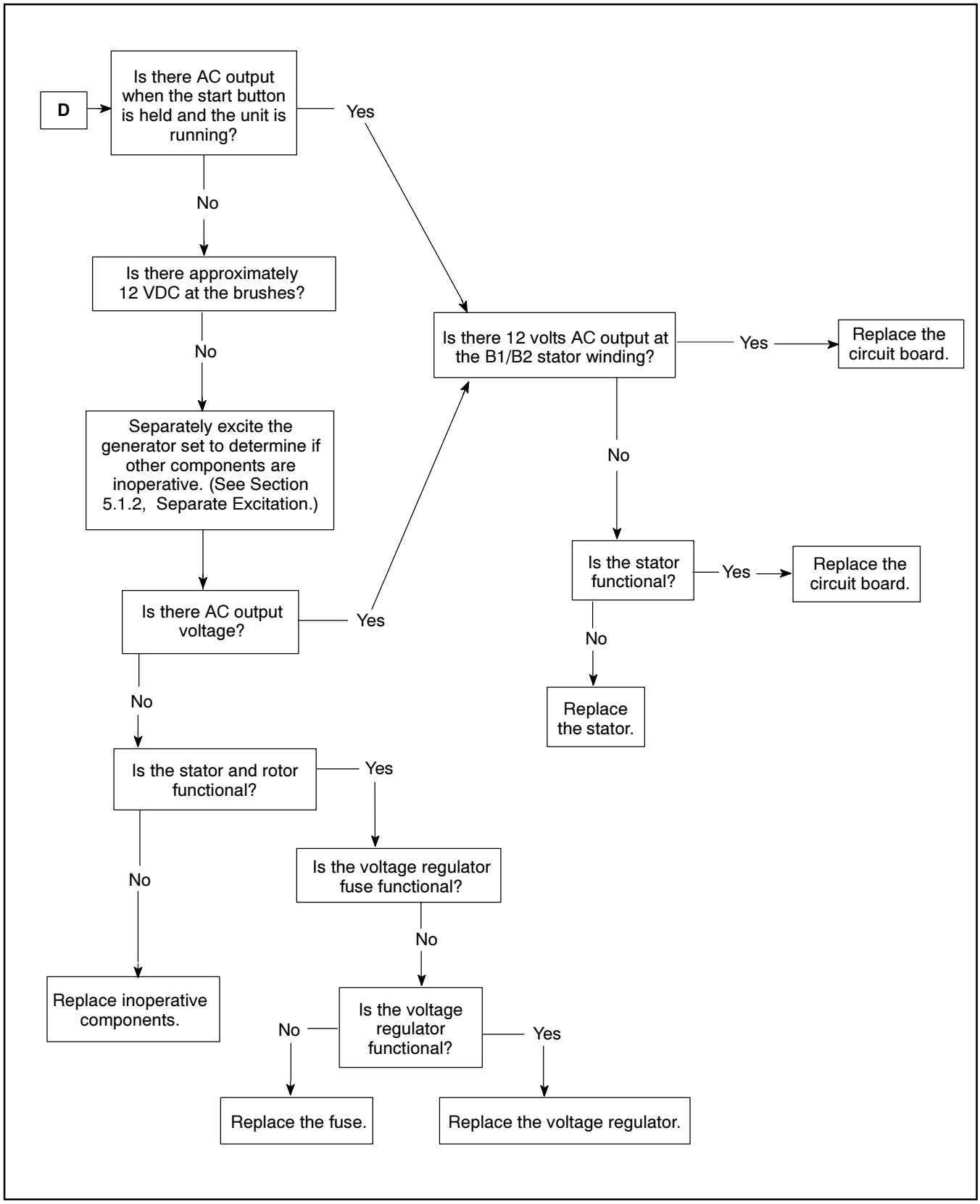


Figure 4-6 Troubleshooting the Relay Controller Circuit Board (4 of 4)

5.1 General

Before beginning the following troubleshooting procedures, read all the safety precautions at the beginning of this manual. The following tests include additional safety precautions; OBSERVE THESE PRECAUTIONS!

⚠ WARNING

Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator.
(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove wristwatch, rings, and jewelry before servicing the equipment.

5.1.1 General Troubleshooting

To determine the cause of no- or low-AC output , refer to the following steps and the troubleshooting flow chart (Figure 5-1). Verify the operation of the alternator components before replacing the controller board or voltage regulator.

General Troubleshooting:

1. Check the condition of the voltage regulator's 10-amp fuse.

2. If the fuse is functional, separately excite the generator. (See Section 5.1.2.) The separate excitation test duplicates the role of the voltage regulator by providing excitation current to the rotor.

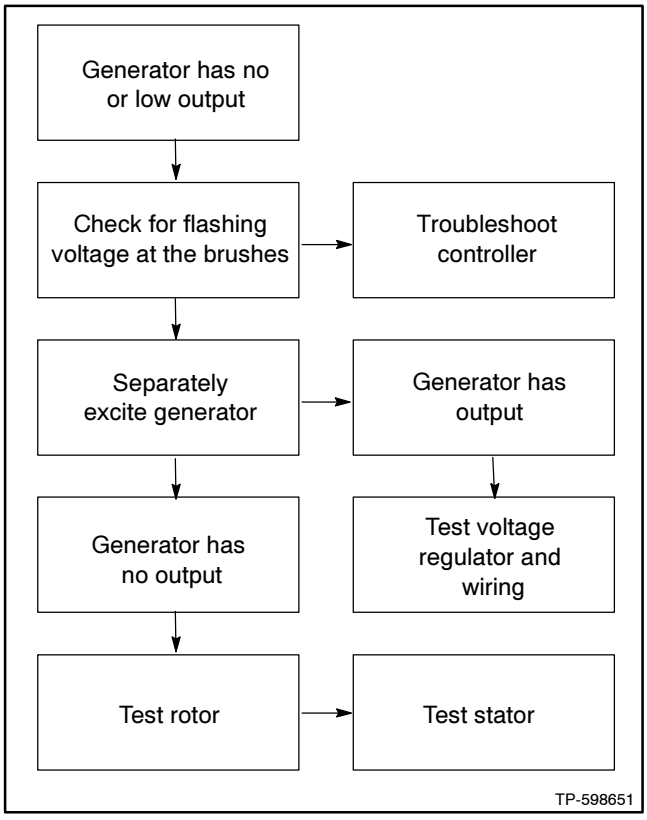


Figure 5-1 General Troubleshooting

5.1.2 Separate Excitation

By separately exciting the generator to determine the presence of a faulty voltage regulator, it is possible to determine if a running fault exists in the rotor and/or stator. A generator component that appears functional while static (stationary) may exhibit a running open or short circuit while dynamic (moving). Centrifugal forces acting on the windings during rotation or insulation breakdown as temperatures increase can cause short circuits.

Note: It is not necessary to separately excite the generator if there is AC output with flashing voltage.

Separate Excitation Procedure:

1. Disconnect all of the leads from the voltage regulator.

2. Disconnect the P10 (F1, F2) connector.

3. Connect a separate excitation circuit as shown in Figure 5-2. Connect an ammeter and a 10-amp fuse in series with F1. Note and record the ammeter reading.

4. Divide the battery voltage by the exciter resistance (cold) to determine the exciter current. Disconnect the resistor leads and determine the exciter current value using an ohmmeter. See Section 1.3, Specifications, for the normal values.

$$\text{Exciter Current} = \frac{\text{Battery Voltage}}{\text{Exciter Resistance}}$$

$$\text{Example}: \frac{12\ \text{VDC}}{3.7\ \text{Ohms}} = 3.2\ \text{Amps}$$

5. Start the engine and check that the ammeter remains stable. An increasing meter reading indicates a shorted rotor. A decreasing meter reading to zero, or unstable reading, suggests a running open in the rotor. If the ammeter is stable, continue with step 6.

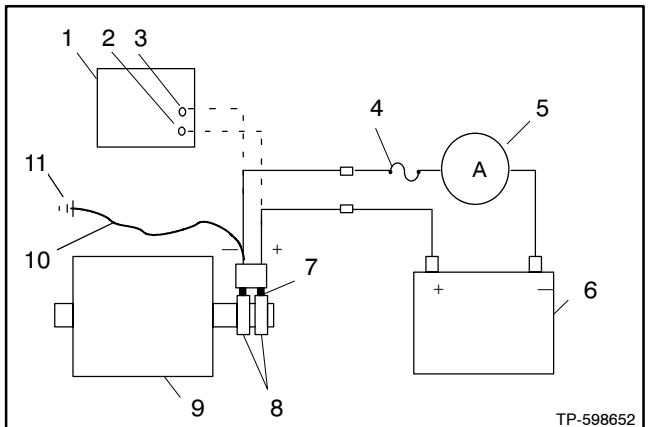
6. With a jumper wire, ground the negative (–) lead from the rotor to the engine block. An increased current reading or a fluctuating reading indicates a grounded rotor winding. Replace the rotor if the ammeter reading fluctuates. If the ammeter is stable, continue with step 7.

7. Remove the jumper wire and reverse the positive (+) and negative (–) leads on the rotor. Repeat step 5. If the ammeter is stable, ground the negative (–) lead at its new location on the rotor to the engine block. Replace the rotor if the ammeter reading fluctuates.

8. Check for AC output across the stator leads and compare the measured output to the values in Section 1, Specifications. If the output varies considerably from those listed, a faulty stator, rotor, rectifier module, or armature is the likely cause.

If there is no generator output during normal operation, but output is available when the generator set is separately excited, the voltage regulator may be inoperative.

Note: See Section 1, Specifications, for the stator output voltages (with separately excited generator). These specifications are based on 12 volts at the battery. Should the battery voltage vary, the resulting stator output values will also vary.



1. Voltage regulator
2. (+) Terminal—(P10-1)
3. (–) Terminal—(P10-2)
4. 10-amp fuse
5. DC ammeter
6. 12-volt battery (DC)
7. Brushes
8. Collector rings
9. Main field (rotor)
10. Jumper lead
11. Engine ground

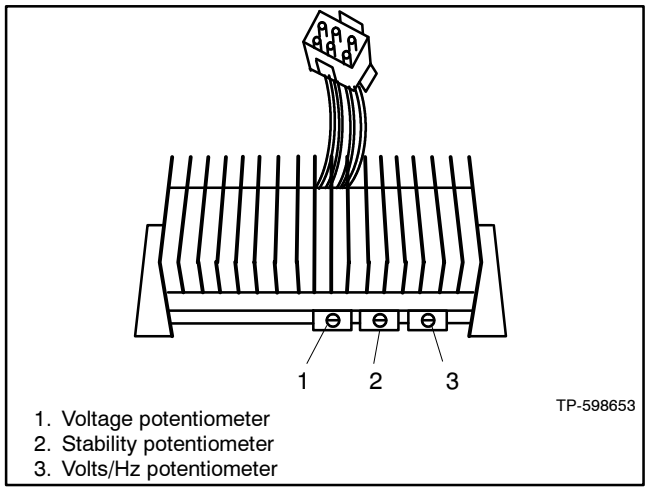
Figure 5-2 Separate Excitation Connections

5.2 PowerBoost™ IIIE Voltage Regulators

The generator set is equipped with a PowerBoost™ IIIE voltage regulator. See Figure 5-3.

The voltage regulator monitors the output voltage of the generator set.

The 10-amp regulator fuse protects the alternator stator windings (power supply) 55–33 from excessive current draw because of an inoperative voltage regulator or a downstream short. If the regulator's 10-amp fuse blows, the generator set will shut down. Verify that the regulator fuse is functional before proceeding with the test.



1. Voltage potentiometer
2. Stability potentiometer
3. Volts/Hz potentiometer

Figure 5-3 PowerBoost™ IIIE Voltage Regulator

5.2.1 Voltage Regulator Test

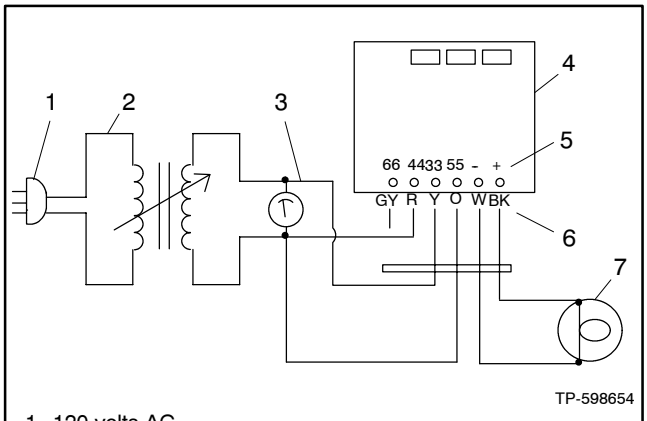
Perform the following test to check the regulator output. Use the following components to test the voltage regulator:

- Variable transformer, 0–140 volts, 0.5-amp minimum
- Plug, 120 volts AC
- Lamp, 120 volts, 100 watts
- AC voltmeter
- Insulated copper wire, #14 AWG, minimum

Regulator Test Procedure:

1. Connect the components as shown in Figure 5-4.
2. Turn the variable transformer setting to zero. Plug in the variable transformer.
3. Turn the variable transformer on. Slowly increase the variable transformer to 100 volts. The test lamp should light. If the lamp does not light, turn the voltage adjustment potentiometer (pot) clockwise. If the lamp still does not light, the voltage regulator is inoperative. Replace the voltage regulator. An inoperative voltage regulator causes a generator no/low-output condition.
4. Slowly increase the variable transformer to 120 volts. The lamp should go out and stay out as the voltage increases. If the lamp remains lit, turn the voltage adjustment pot counterclockwise. If the lamp still remains lit, replace the voltage regulator. A voltage regulator that is inoperative causes a generator high voltage output condition.
5. Turn the variable transformer to zero and unplug the AC cord.

   Note: For applications requiring fine voltage adjustment, connect a remote rheostat to voltage regulator terminal 66.

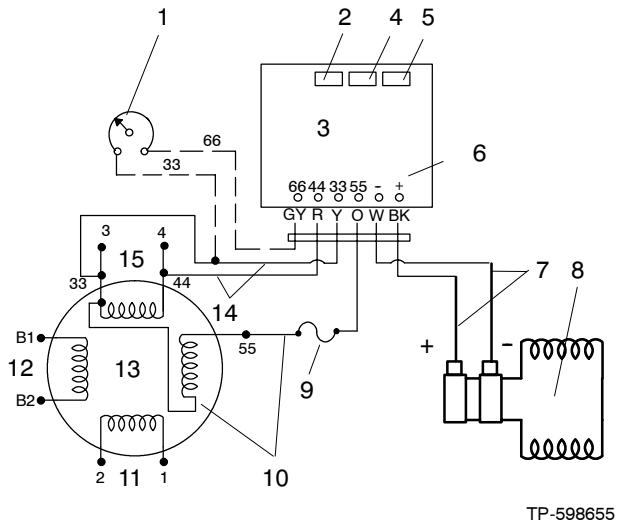


1. 120 volts AC
2. Variable transformer
3. AC voltmeter
4. Voltage regulator PowerBoost™ IIIE
5. Stator/rotor connections (for reference only)
6. Lead color
7. 120-volt, 100-watt lamp

Figure 5-4 PowerBoost™ IIIE Voltage Regulator Test

5.2.2 Voltage Regulator Adjustment

The factory sets the voltage regulator and, under normal circumstances, the regulator requires no further adjustment. However, if the voltage regulator has been replaced or tampered with or if voltage/frequency reconnection has been done, readjust the voltage regulator according to the following procedure. See Figure 5-5. The following paragraphs describe the voltage regulator components.



1. Optional remote rheostat
2. Voltage adjustment pot
3. PowerBoost™ IIIE voltage regulator
4. Stabilizer pot
5. Volts/Hz pot
6. Stator/rotor connections (for reference only)
7. DC output
8. Rotor
9. 10-amp fuse
10. AC power input (aux.)
11. Main (2 and 1)
12. Control
13. Stator
14. Sensing
15. Main (3 and 4)

Figure 5-5 PowerBoost™ IIIE Voltage Regulator

Voltage Adjustment Pot adjusts the generator output within the range of 100–130 volts.

Stabilizer Pot fine tunes regulator circuitry to minimize AC voltage fluctuation.

Volts/Hz Pot allows the voltage to drop if the load imposed on the generator causes the engine speed to fall below a predetermined frequency (roll-off point). This reduction of voltage results in a decrease of starting kW (load) allowing the governor to recover the engine speed.

Voltage Regulator Adjustment Procedure:

1. Stop the generator set.
2. Turn the remote rheostat, if equipped, to the midpoint. Turn the voltage and stabilizer pots fully counterclockwise. Connect the voltmeter to the AC circuit or an electrical outlet.
3. Start the generator set.
4. Adjust the generator frequency using a frequency meter. Set the no load speed at 52.5 Hz for 50 Hz operation or 63 Hz for 60 Hz operation. Rotate the voltage adjustment pot clockwise to increase the voltage or counterclockwise to decrease the voltage to achieve the desired output voltage.
5. Connect a 120-volt light bulb to the AC plug on the generator set.
6. Rotate the stability pot clockwise until the light bulb flickers minimally.
7. Readjust the voltage to achieve the desired output voltage.
8. Disconnect the 120-volt light bulb.
9. Turn the volts/Hz pot completely clockwise to decrease the Hz roll-off point. See Figure 5-6.

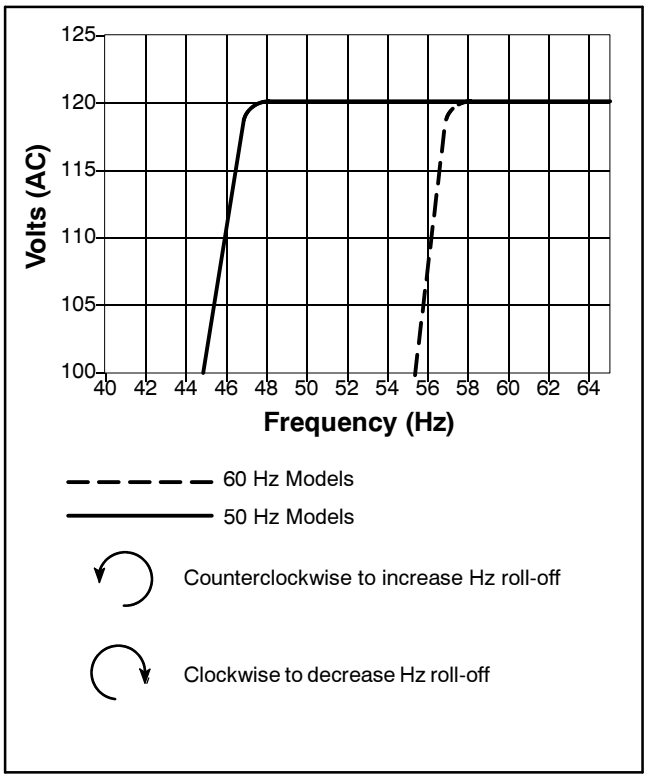


Figure 5-6 Volts/Hz Roll-Off Chart

10. Set the engine speed to 47.5 Hz for 50 Hz generator sets and 57.5 Hz for 60 Hz generator sets for the desired cut-in frequency.

11. Slowly turn the volts/Hz pot counterclockwise until the frequency matches that of the engine frequency (47.5 or 57.5 Hz) or until the voltage just begins to drop.

12. Reset the engine speed to the normal frequency (50 Hz or 60 Hz).

13. Recheck the AC voltage output and stability as described in steps 4–7.

14. Stop the generator set.

5.3 Rotor

The two-pole rotor creates the magnetic field needed to sustain alternating current in the stator windings. Before testing, inspect the rotor for visible damage to pole shoes, insulation, exposed coil windings, and collector ring surfaces. Check the rotor bearing for noisy operation, excessive wear, radial or axial movement, and/or heat discoloration. Replace the rotor as necessary.

Collector rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly machined appearance. Wipe the collector rings with a dry, lint-free cloth. Use a commutator stone to remove the groves on the collector rings. Do not use emery or carborundum paper or cloth. Remove all carbon dust from the generator. Remove the black or pitted surface of the collector rings using a lathe.

Check the rotor for continuity and resistance. Lift the brushes and measure the rotor resistance between the two collector rings. See Section 5.5.

Note: When checking rotor resistance with the rotor installed, brushes must not be in contact with rotor collector rings. Use a brush retainer on brushes for accurate resistance readings.

Note: Use the values in Section 1 as a reference for rotor resistance readings. Take readings at room temperature or about 21°C (70°F). Rotor resistance will vary directly with increase in temperature.

To check whether the rotor is shorted to ground, touch one ohmmeter lead to either collector ring and the other lead to the rotor poles or shaft. The meter should register no continuity.

Repair or replace the rotor if the previous tests detect any faults.

5.4 Stator

The stator consists of a series of coils of wire laid in a laminated steel frame. The stator leads supply voltage to the AC load and exciter regulator. See Figure 5-7 for coil lead description.

Stator Leads	Description
1–2	Output coil
3–4	Output coil
33–44	Control wires from 3 and 4
55–33	Voltage regulator power source
B1–B2	Controller power source

Figure 5-7 Stator Coil Lead Description

Before testing the stator, inspect it for heat discoloration and visible damage to the exposed coil windings and varnished areas of the frame laminations. Be sure the stator is securely fastened in the stator housing.

The stator produces electrical output (AC) as the magnetized main field rotates within the stator windings. Test the condition of the stator according to the following procedure.

Leads 1, 2, 3, and 4 are the generator output leads. Leads 33, 44, and 55 are the voltage regulator supply and sensing leads. The output of leads B1 and B2 is the control voltage for the controller.

Stator Test Procedure:

1. Place the generator start/stop switch in the STOP position.

2. Disconnect the generator set engine starting battery, negative (-) lead first.

3. Check the generator output lead connections. See Section 8, Reconnection and Wiring Diagrams.

4. Disconnect all of the stator leads to isolate the windings. To check the stator continuity, set the ohmmeter on the R x 1 scale. Check the stator continuity by connecting the meter leads to the stator leads as shown in Figure 5-8. Perform the stator tests on all of the stator windings.

   Note: When taking an ohmmeter reading using lead 55, make the connection prior to the in-line fuse.

5. Check the cold resistance of the stator windings by connecting the meter leads to the stator leads 1-4, 2-5, 3-6, etc. See Section 1, Specifications, for the stator resistance values.

6. Perform a megohmmeter test on the stator as described in step 7.

   Note: Consider the stator functional if the resistance reading (continuity) is low and there is no evidence of shorted windings (heat discoloration).

   Note: The stator resistance varies directly with increased temperature.

If the stator readings vary considerably during the previous checks, repair or replace the stator.

7. Check the stator for a grounded condition using a megohmmeter. Apply 500 volts DC to any stator lead from each winding and the stator frame. Follow the instructions of the megohmmeter manufacturer when performing this test. Repeat the test on the other leads until all of the stator windings have been tested. A reading of approximately 1.5 megohms and higher indicates the stator is functional. A reading of less than approximately 1.5 megohms indicates deterioration of the winding insulation and possible current flow to ground; if so, replace the stator.

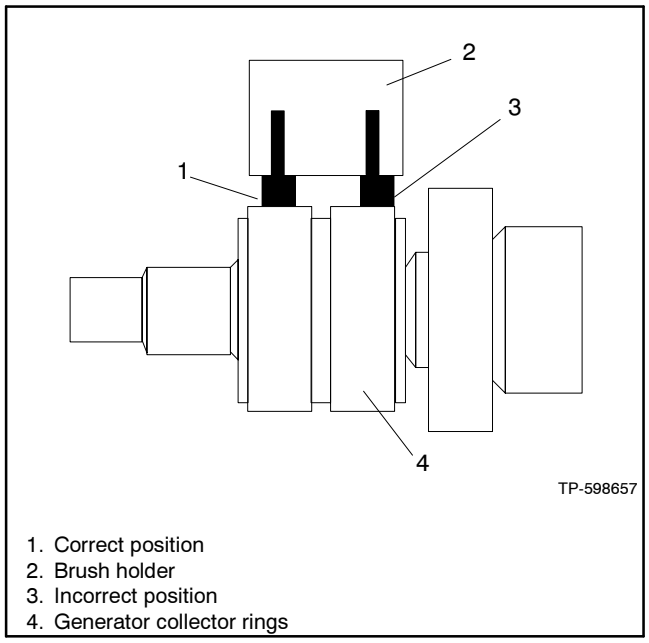
Between Leads	Continuity
1 and 2	Yes
3 and 4	Yes
55 and 66	Yes
B1 and B2	Yes
1 and 3, 4, 33, 44, 55	No
1 and 55, B1 and B2	No
4 and B1 and B2	No
55 and B1 and B2	No
Any stator lead and ground	No

Figure 5-8 Stator Continuity

5.5 Brushes

The brushes provide a current path from the voltage regulator to the collector rings. Because the brushes carry a low current, inspect them every 3000 hours. Abrasive dust on the collector rings could shorten the life of the brushes. Excessive arcing at the brushes could damage the voltage regulator. Weak springs, damaged collector rings, sticking brushes, a loose holder, or poor brush contact can cause arcing at the brushes. See Figure 5-10 for brush component identification.

The brushes must be free to move within the holder and be held in contact by the springs. When properly positioned, spring pressure on the brush surface will cause the brush to wear evenly. The brushes must ride 100% on the collector rings or arcing will occur and cause burned rings or failure of the voltage regulator. Figure 5-9 shows the correct positioning of the brushes. Add or remove alignment shims as necessary to center the brushes on the collector rings.



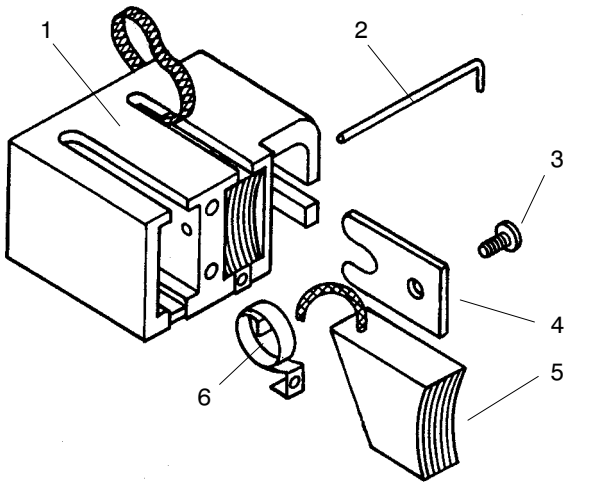
1. Correct position
2. Brush holder
3. Incorrect position
4. Generator collector rings

Figure 5-9 Brush Positioning

Replace brushes if they show excessive or uneven wear.

Use a retainer wire (such as a paper clip) to contain the brushes during disassembly and reassembly. Push the brushes into the brush holder until the retainer wire can be inserted into the brush keeping hole.

Replace brushes when they are worn to half of their original size.



1. Brush holder
2. Retainer (paper clip)
3. Mounting screw
4. Alignment shim(s)
5. Brush
6. Spring

Figure 5-10 Brush Holder

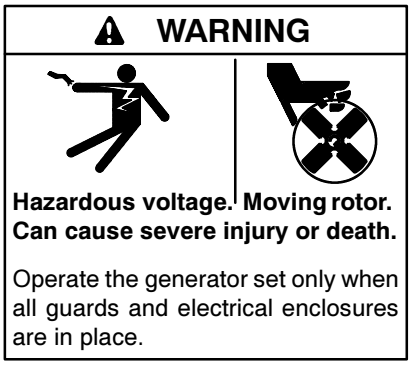
Notes

6.1 Engine/Generator Components

See Figure 6-1 through Figure 6-3 for engine/generator component testing. With the generator set battery connected, check the wiring harness and the engine/generator components listed in the following tables. Check each component using a multimeter to verify that the switches function and that voltage is present at each component.

Component	Voltmeter Connections	Procedure	Results
Hourmeter and wiring.	Connect the red test lead to the hourmeter positive (+) terminal. Connect the black test lead to the hourmeter negative (–) terminal.	Set the voltmeter to 12 volts DC or greater. Start the generator set.	A 12 volt DC reading indicates the wiring harness is functional.
	None (see procedure).	Disconnect the hourmeter leads and apply 12 volts DC to the hourmeter. The hourmeter is polarity sensitive.	If functional, hourmeter operates.
Stator auxiliary winding B1 and B2.	Connect the AC voltmeter leads to the B1 and B2 windings at connector P11.	Stop the generator set. Set the voltmeter to 20 volts AC or greater. Crank the generator set and allow the set to reach its rated speed.	A reading of 12–15 volts AC indicates a functional B1/B2 winding.

Figure 6-1 Engine/Generator Component Testing, Relay Controller


WARNING
Hazardous voltage. Moving rotor.
Can cause severe injury or death.
Operate the generator set only when all guards and electrical enclosures are in place.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove wristwatch, rings, and jewelry before servicing the equipment.

To further check the generator set components, disconnect the battery and remove the wiring harness plugs from the controller circuit board. Use an ohmmeter to check the continuity of the components and to isolate inoperative components. Refer to Figure 6-2 and Figure 6-3.

Note: Before performing ohmmeter checks, disconnect the generator set battery to prevent damage to the ohmmeter.

Component	Ohmmeter Connections	Procedure	Results
Start/stop switch.	Connect the ohmmeter to the P2-6 and P2-4 leads.	Place the ohmmeter on the R x 1000 scale. Place the rocker switch in the START position.	If the switch is functional, zero ohms continuity. Any resistance other than zero or very low ohms, replace the switch.
	Connect the ohmmeter to the P2-6 and P2-5 leads.	Place the ohmmeter on the R x 1000 scale. Place the rocker switch in the STOP position.	If the switch is functional, zero ohms continuity. Any resistance other than zero or very low ohms, replace the switch.
K20 relay coil and wiring.	Connect the ohmmeter to the P1-4 and P1-9 leads.	Place the ohmmeter on the R x 1 scale.	If functional, 85 ohms. Low resistance, shorted K20 relay coil and/or wiring. High resistance, open K20 relay and/or wiring.
Controller 10-amp fuse and wiring.	Connect the ohmmeter to the battery positive (+) cable and the P1-14 lead. **Note**: Connect the J4 and P4 leads to perform this test.	Place the ohmmeter on the R x 1000 scale.	If functional, zero or very low ohms. No reading (infinity), open circuit or blown fuse.

Figure 6-2 Engine/Generator Component Testing, Relay Controller

Component	Ohmmeter Connections	Procedure	Results
Main field (rotor).	Disconnect the P10 and P11 connectors and connect the ohmmeter to P10-1 and P10-2 leads.	Place the ohmmeter on the R x 1 scale.	Low resistance indicates shorted rotor windings. High resistance indicates an open in the rotor windings. See Section 1, Specifications.
B1/B2 stator windings.	Connect the ohmmeter to the P11-1 and P11-2 leads. **Note:** Disconnect P11 and J11 to perform this test.	Place the ohmmeter on the R x 1 scale.	Low resistance indicates shorted B1/B2 windings. High resistance indicates an open in the B1/B2 windings. See Section 1, Specifications.
P1 ground connection.	Connect the ohmmeter to the P1-9 and ground.	Place the ohmmeter on the R x 1 scale.	If functional, zero ohms (continuity). Any other reading indicates a poor ground connection.
Low oil level (LOL) safety shutdown switch.	Connect the ohmmeter to the P4-6 and engine block (ground).	Place the ohmmeter on the R x 1000 scale. The oil level in the engine must be drained for this test. Replace the engine oil after this test.	If functional, zero ohms (continuity). Then, disconnect LOL switch lead and isolate the terminal. Meter reading should show an open circuit.

Figure 6-3 Engine/Generator Component Testing, Relay Controller

6.2 Remote Panel (optional)

Kohler Co. offers a remote panel with a start/stop switch and a hourmeter for connection to the generator set.

If difficulty with the remote operation occurs, test the switch. See Figure 6-4 and Section 8.4 for troubleshooting the remote start/stop switch.

Component	Ohmmeter Connections	Procedure	Results
Start/stop switch.	Remote switch: yellow/red wire terminal and black wire terminal.	Place the ohmmeter on the R x 1 scale. Place the rocker switch in the START position.	Continuity indicates a functional switch. No reading indicates an inoperative switch. Replace the switch
	Remote switch: grey/black wire terminal and black wire terminal.	Place the ohmmeter on the R x 1 scale. Place the rocker switch to the STOP position.	Continuity indicates a functional switch. No reading indicates an inoperative switch. Replace the switch

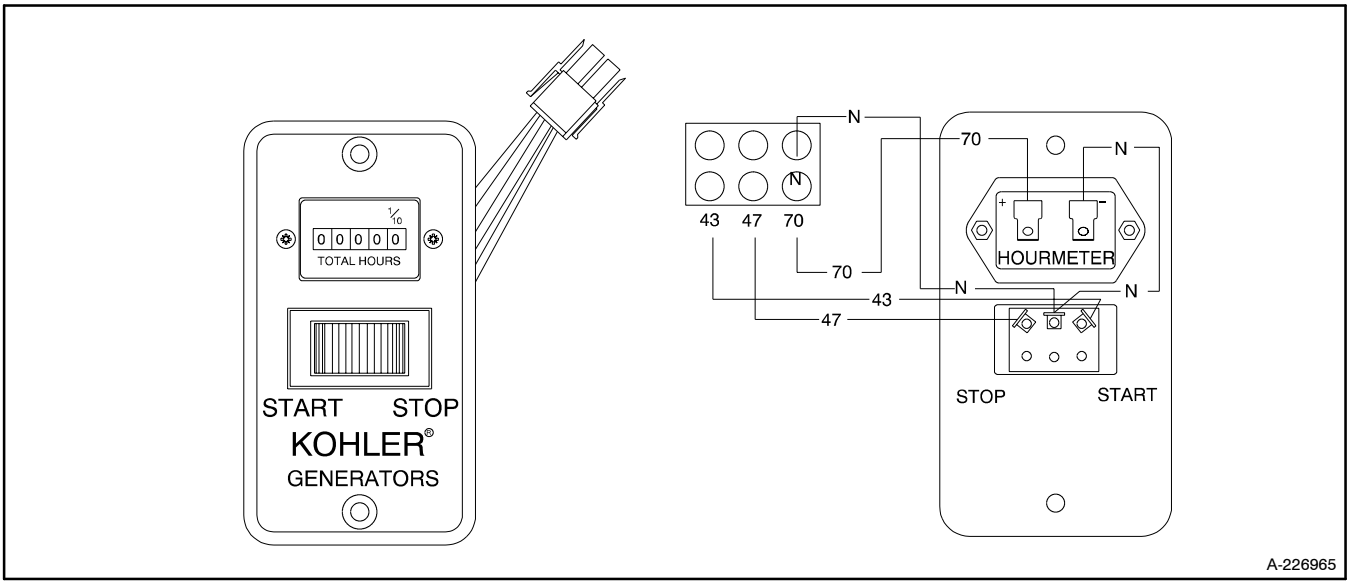


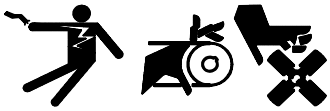
Figure 6-4 Remote Start Panel Troubleshooting

Notes

7.1 Disassembly

Disconnect the external connections—battery cables at the battery (negative (–) lead first), AC-output leads in the controller, remote start panel at the controller P3 connector, and the fuel line at the fuel pump filter inlet. Observe all of the safety precautions listed during the disassembly/reassembly procedures.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

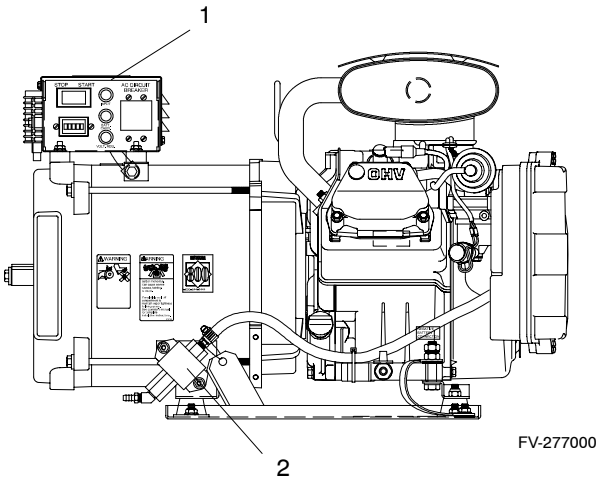
The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Disassembly Procedure:

1. Place the start/stop switch in the STOP position.
2. Disconnect the generator set engine starting battery, the negative (–) lead first.
3. Remove the controller cover.
4. Disconnect the P4 (22-pin) connector from J4.
5. Disconnect the controller ground strap (engine side).

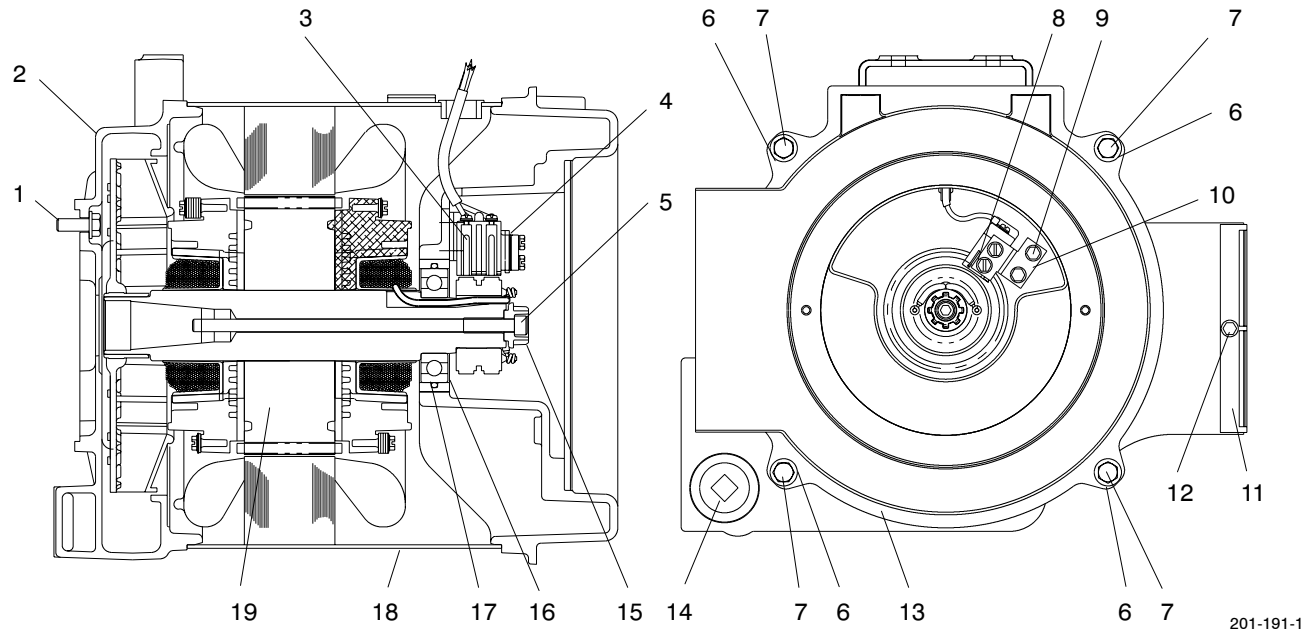
   Note: It is possible to connect the output leads in various positions for different voltage configurations. Mark the leads for correct reconnection.

6. Disconnect the generator output leads 1, 2, 3, and 4 from the circuit breaker and the neutral stud (L0).
7. Disconnect the P11 (FP and FN) and P10 (F1 and F2) connectors.
8. Lift the controller from the rubber mounts while guiding the leads through the bottom hole of the controller box.
9. Remove the fuel pump and fuel inlet line from the generator. See Figure 7-1.
10. Remove the coverplate.
11. Push the brushes into the holder. Secure the brushes into position by sliding a retainer into the brush keeping holes. Refer to Section 5.5.
12. Remove the brush holder and carefully slide the leads out of the stator housing. See Figure 7-2.
13. Remove the generator side vibromount nuts.
14. Tilt the generator set up and brace it with a block of wood. See Figure 7-3.
15. Remove the end bracket overbolts. Use a rubber mallet to separate the end bracket from the stator housing. See Figure 7-3.
16. Carefully remove the stator assembly from the generator adaptor plate.
17. Loosen the rotor bolt, finger tighten, and back off two turns.
18. Strike the bolt with a hammer until the rotor is freed from the engine tapered drive shaft. Do not damage the bolt threads or the bolt head. See Figure 7-4.



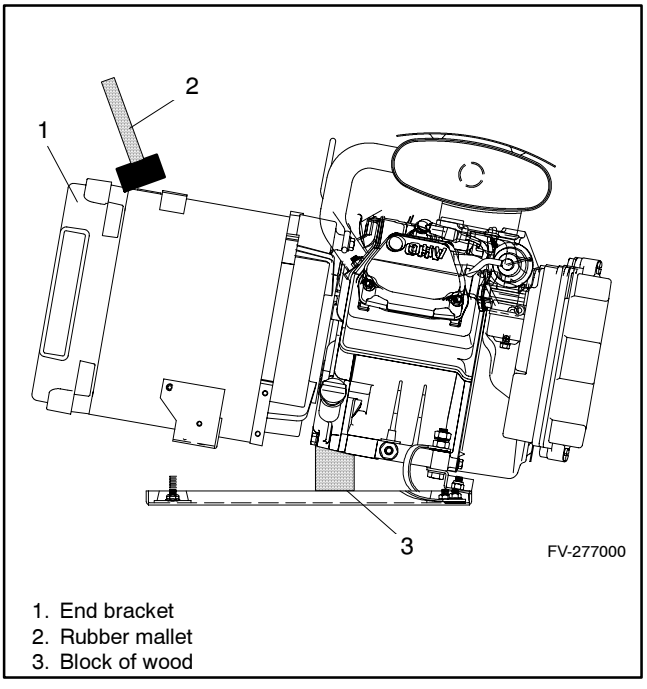
1. Controller
2. Fuel pump

Figure 7-1 Fuel Pump and Controller Removal



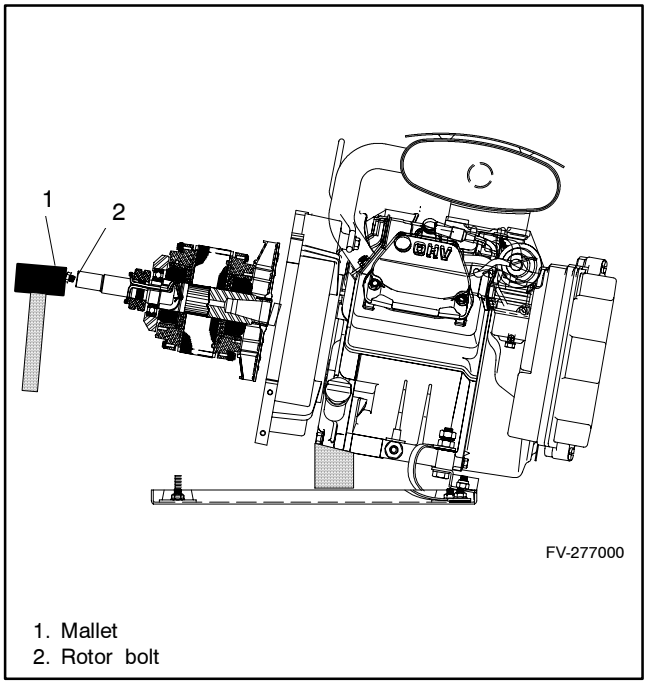
1. Generator adapter plate bolt, quantity 4
2. Generator adapter
3. Brush holder assembly
4. Brush holder shim
5. Rotor bolt
6. Hardened washer
7. Generator overbolt, quantity 4
8. Retainer wire
9. Brush assembly mounting screws, quantity 2
10. Bracket, brush holder
11. Fan guard
12. Fan guard bolts, quantity 2
13. End bracket
14. Pipe plug
15. End drive fitting (for marine application only)
16. End bracket bearing
17. O-ring
18. Stator assembly
19. Rotor assembly

Figure 7-2 Alternator Components



1. End bracket
2. Rubber mallet
3. Block of wood

Figure 7-3 Raising the Generator



1. Mallet
2. Rotor bolt

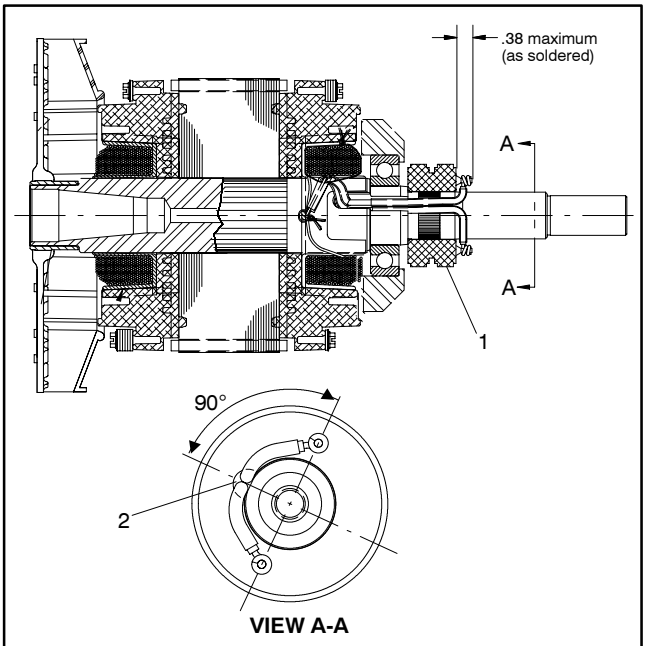
Figure 7-4 Rotor Removal

7.2 Collector Ring and Bearing Replacement

1. Unsolder the collector ring leads from the collector ring terminals.
2. Remove the collector rings with a 3-jaw puller.
3. Remove the bearing with a 3-jaw puller.
4. Press the new bearing onto the rotor shaft.
5. Align the collector ring keyway with the keyway on the rotor shaft. See Figure 7-5.
6. Press the new collector rings onto the rotor shaft.

   Note: The new collector rings must be turned down to a finish of 32 microinches using a lathe and commutator stones. Turn down the collector rings on the rotor shaft. See Figure 7-6.

7. Solder the leads onto the collector ring terminals. The connection is not to exceed 9.65 mm (0.38 in.) beyond the collector rings. See Figure 7-5.
8. Test to ensure continuity at the collector rings.



1. Collector ring leads
2. Keyways

Figure 7-5 Rotor Assembly

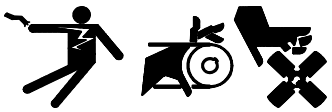
Minimum diameter, mm (in.)	57.15 (2.250)
Maximum finish, microinches	32.00
Maximum eccentricity, mm (in.)	0.08 (0.003)
Maximum out-of-round, mm (in.)	0.01 (0.0002)

Figure 7-6 Collector Ring Dimensions

7.3 Reassembly

1. Apply antiseize compound to the tapered shaft of the engine.
2. Align the rotor onto the engine shaft and secure the rotor with the rotor bolt. Torque the rotor bolt to 23.1 Nm (204 in. lb.).
3. Carefully slide the stator assembly over the rotor.
4. Install the end bracket and torque the overbolts to 13.6 Nm (120 in. lb.). See Figure 7-2.
5. Feed the brush leads inside the stator housing up through the opening. Secure the brush holder using the original screws.
6. Remove the brush retainer wire and check the brush alignment. See Section 5.5.
7. Install the coverplate and torque it to 6.8 Nm (60 in. lb.).
8. Install the fuel line and fuel pump.
9. Guide the leads from the stator through the bottom opening of the controller. Secure the controller.
10. Reconnect the leads from the stator to the controller using the reverse procedure of that listed in Section 7.1. Refer to Section 8, Reconnection and Wiring Diagrams.
11. Connect the generator set starting battery, the positive (+) lead first.
12. Test the generator operation.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Disconnect the power to the battery charger, if equipped. (2) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

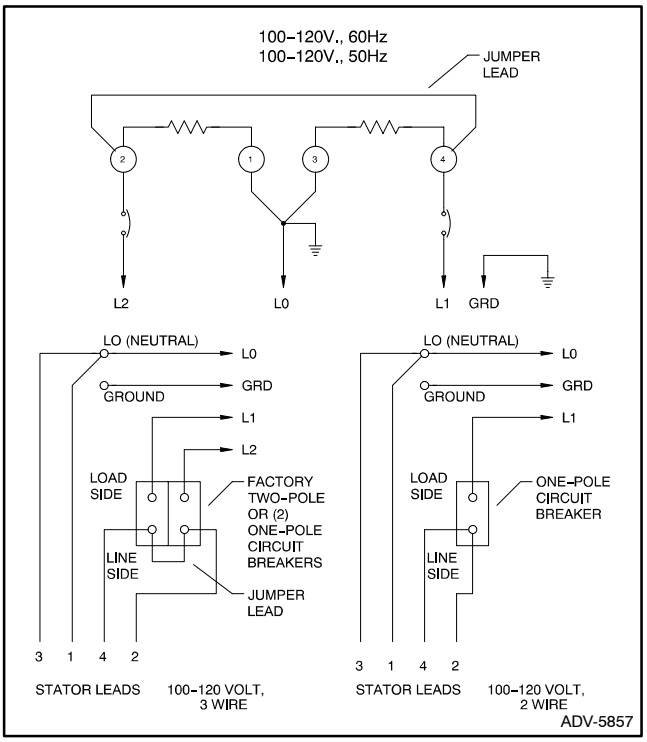
⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

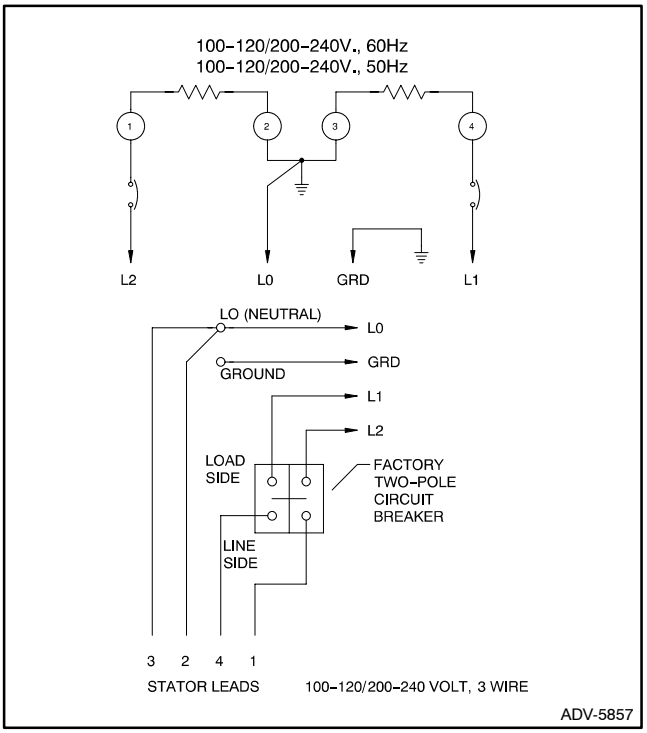
Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

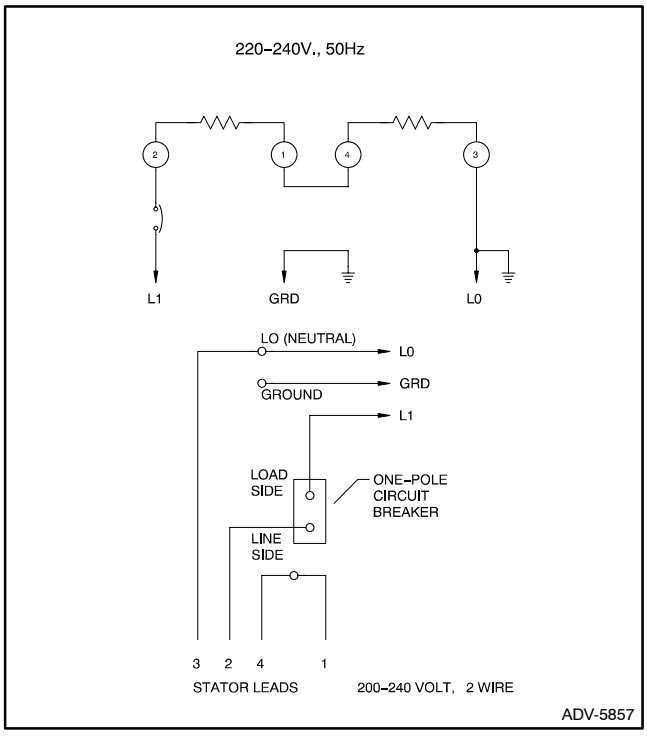
8.1 Reconnection Diagram 100–120 V, 60 & 50 Hz



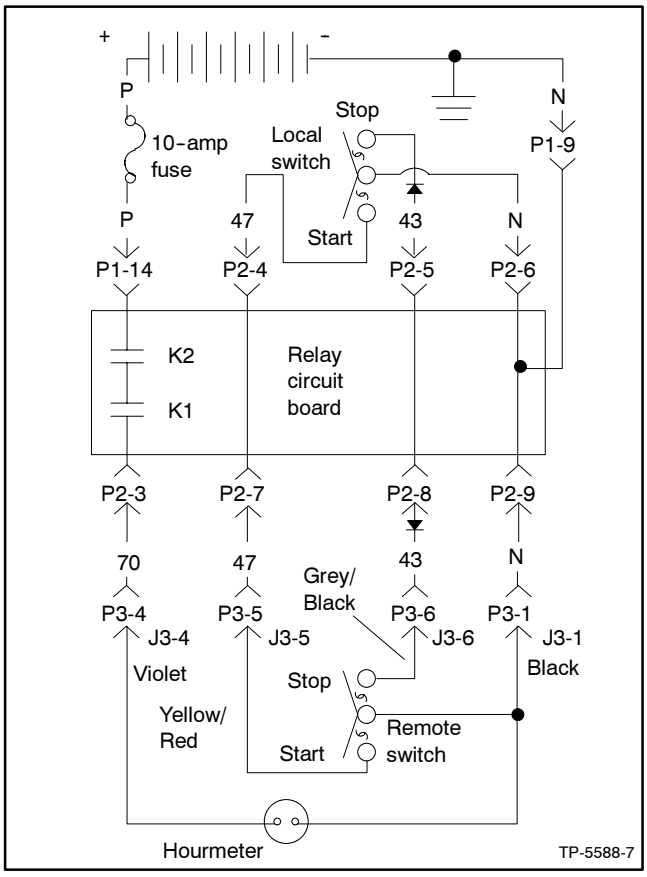
8.2 Reconnection Diagram 100–120/200–240 V, 60 & 50 Hz



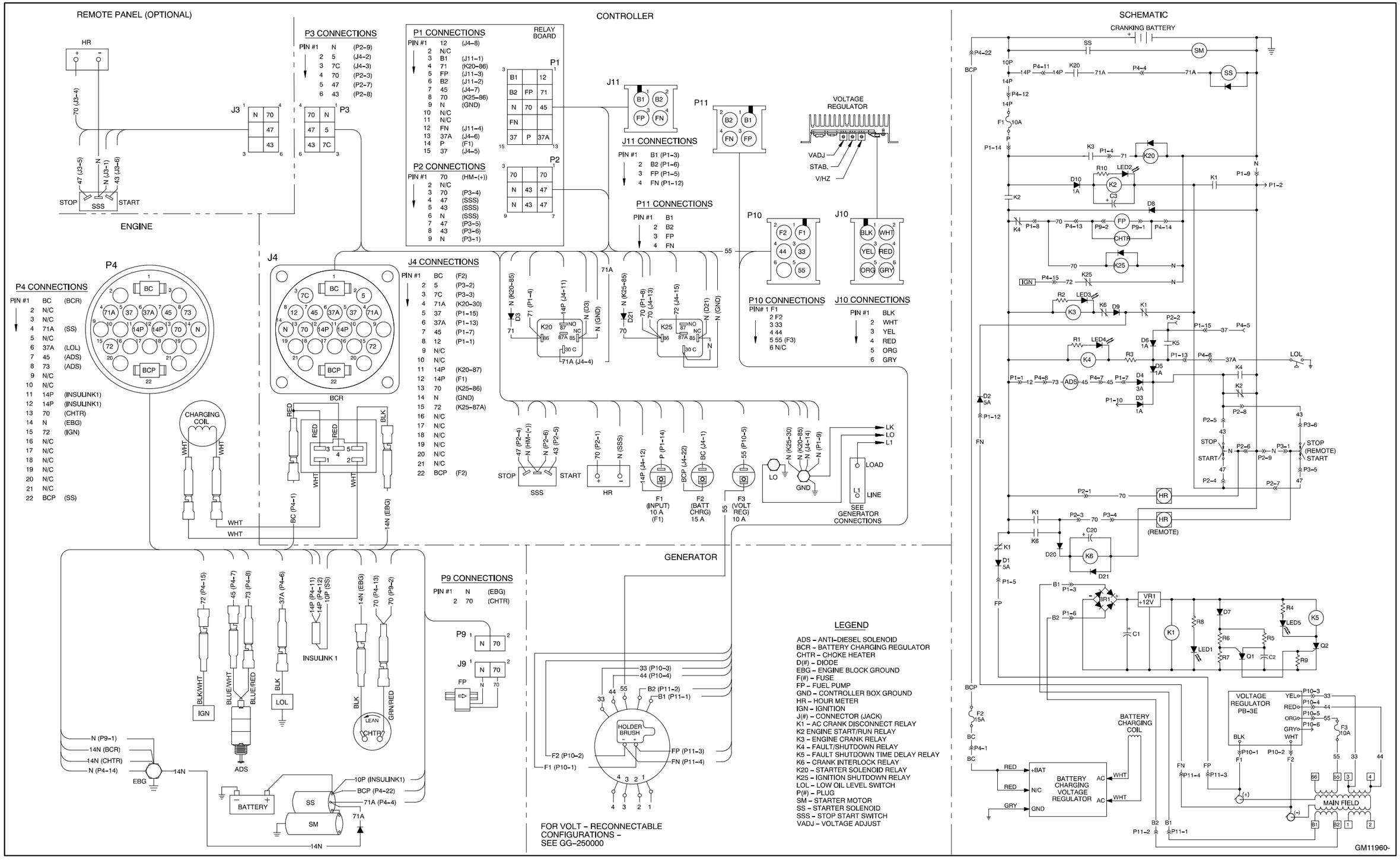
8.3 Reconnection Diagram 220–240 V, 50 Hz



8.4 Remote Start Panel



8.5 Wiring Diagram 5ERKM/4EFRKM



Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audio/visual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
cmm	cubic meters per minute
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
COM	communications (port)
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example *(exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
gnd.	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
kg	kilogram

kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
O/C	overcrank
OD	outside diameter
OEM	original equipment manufacturer
O/F	overfrequency
opt.	option, optional
O/S	oversize, overspeed
OSHA	Occupational Safety and Health Administration
O/V	overvoltage
oz.	ounce
p., pp.	page, pages
PA	packed accessory
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph.	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
U/F	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
U/S	undersize, underspeed
UV	ultraviolet
U/V	undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.

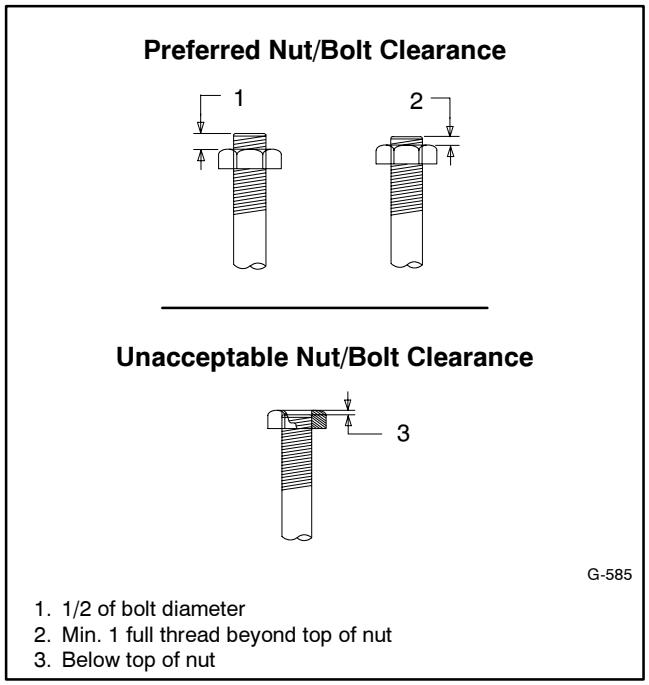


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

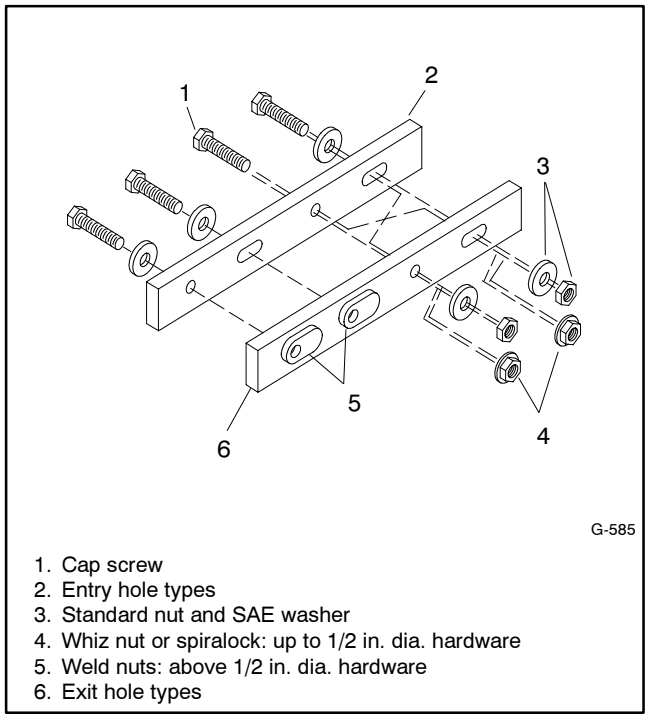


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

Use the following torque specifications when service literature instructions give no specific torque values. The charts list values for new plated, zinc phosphate, or oiled threads. Increase values by 15% for nonplated threads. All torque values are +0%/–10%.

American Standard Fasteners Torque Specifications					
		Assembled into Cast Iron or Steel			Assembled into Aluminum
Size	Torque Measurement	Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	1.8 (16)
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	6.8 (60)
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	8.1 (72)
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	13.6 (120)
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	14.9 (132)
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	24.0 (18)
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	27.0 (20)
7/16-14	Nm (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	—
7/16-20	Nm (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	—
1/2-13	Nm (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	—
1/2-20	Nm (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	—
9/16-12	Nm (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	—
9/16-18	Nm (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	—
5/8-11	Nm (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	—
5/8-18	Nm (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	—
3/4-10	Nm (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (338)	—
3/4-16	Nm (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	—
1-8	Nm (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	—
1-12	Nm (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	—

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)				
	Assembled into Cast Iron or Steel			Assembled into Aluminum
Size (mm)	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	5.6 (4)	9.9 (7)	14.0 (10)	5.6 (4)
M8 x 1.25	13.6 (10)	25.0 (18)	35.0 (26)	13.6 (10)
M8 x 1.00	21.0 (16)	25.0 (18)	35.0 (26)	21.0 (16)
M10 x 1.50	27.0 (20)	49.0 (35)	68.0 (50)	27.0 (20)
M10 x 1.25	39.0 (29)	49.0 (35)	68.0 (50)	39.0 (29)
M12 x 1.75	47.0 (35)	83.0 (61)	117.0 (86)	—
M12 x 1.50	65.0 (48)	88.0 (65)	125.0 (92)	—
M14 x 2.00	74.0 (55)	132.0 (97)	185.0 (136)	—
M14 x 1.50	100.0 (74)	140.0 (103)	192.0 (142)	—
M16 x 2.00	115.0 (85)	200.0 (148)	285.0 (210)	—
M16 x 1.50	141.0 (104)	210.0 (155)	295.0 (218)	—
M18 x 2.50	155.0 (114)	275.0 (203)	390.0 (288)	—
M18 x 1.50	196.0 (145)	305.0 (225)	425.0 (315)	—

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- Length In Inches (Screws and Bolts)
- Threads Per Inch
- Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- Length In Millimeters (Screws and Bolts)
- Distance Between Threads In Millimeters
- Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- Thickness
- External Dimension
- Internal Dimension

Lock Washers

5/8

- Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14		Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Hex Head Bolts (partial thread)

Part No.	Dimensions
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10090-60	M10-1.50 x 90
M931-10100-60	M10-1.50 x 100
M931-12045-60	M12-1.75 x 45
M931-12050-60	M12-1.75 x 50
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12065-60	M12-1.75 x 65
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110
M931-16090-60	M16-2.00 x 90
M931-20065-60	M20-2.50 x 65
M931-20120-60	M20-2.50 x 120
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160

Hex Head Bolts (full thread)

Part No.	Dimensions
M933-04006-60	M4-0.70 x 6
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M933-12030-60	M12-1.75 x 30
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M933-16040-60	M16-2.00 x 40
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60

Pan Head Machine Screws

M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04020-20	M4-0.70 x 20
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12

Flat Head Machine Screws

M965A-05016-20	M5-0.80 x 16

Hex Nuts

Part No.	Dimensions	Type
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-05-50	M5-0.80	Standard
M982-05-80	M5-0.80	Elastic Stop
M6923-06-80	M6-1.00	Spiralock
M934-06-64	M6-1.00	Std. (green)
M982-06-80	M6-1.00	Elastic Stop
M6923-08-80	M8-1.25	Spiralock
M934-08-60	M8-1.25	Standard
M982-08-80	M8-1.25	Elastic Stop
M6923-10-80	M10-1.50	Spiralock
M982-10-80	M10-1.50	Elastic Stop
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-80	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M982-18-80	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-80	M22-2.50	Standard
M982-22-80	M22-2.50	Elastic Stop
M934-24-80	M24-3.00	Standard
M982-24-80	M24-3.00	Elastic Stop

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

* This metric hex bolt's hardness is grade 10.9.

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